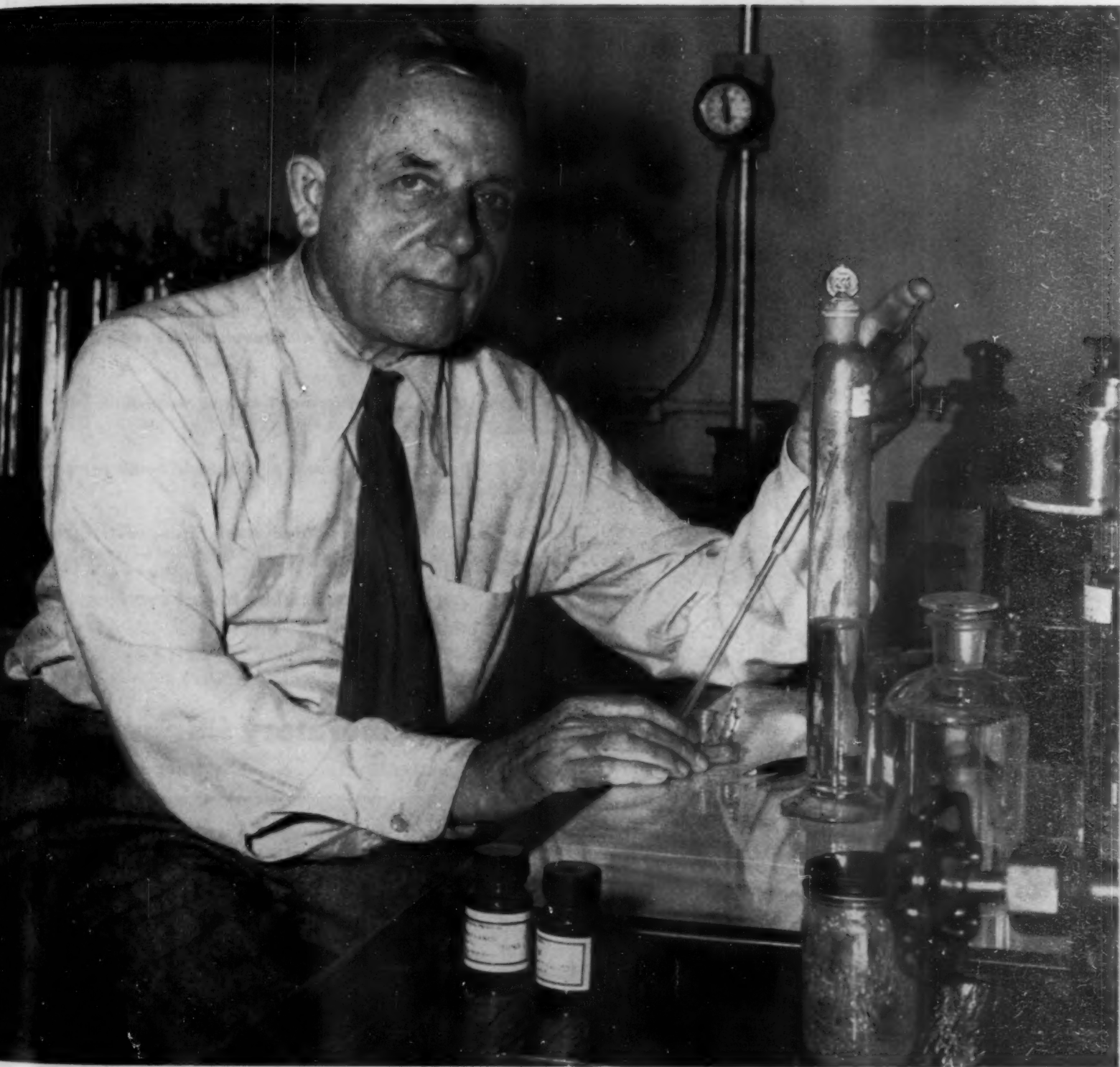


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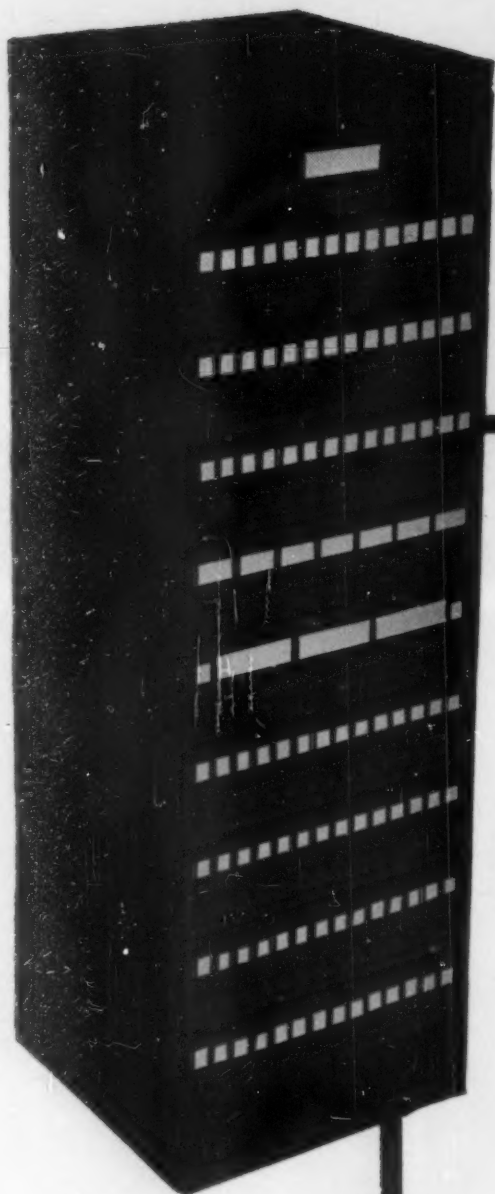
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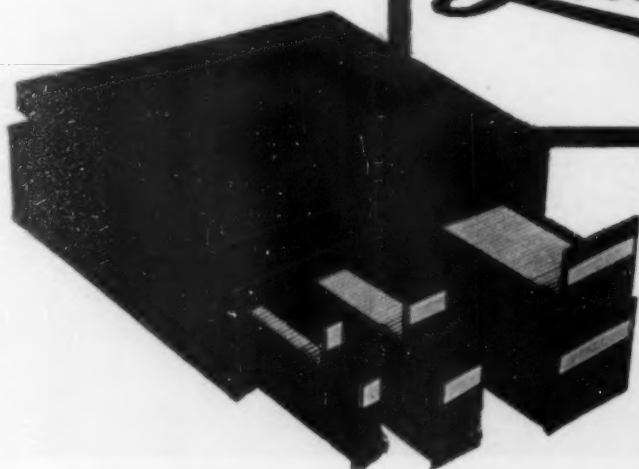
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SCIENCE, November 12, 1948, Vol. 108

Atomic Energy

Eugene P. Wigner

Palmer Physical Laboratory, Princeton University

THE YEARS THAT HAVE PASSED since the discovery of the nuclear chain reaction have not damped our high expectations in the future usefulness of atomic energy for peaceful pursuits. They have, furthermore, helped us to recognize, in addition to the size of this giant, his special skills. However, they have also helped us to realize, perhaps more clearly than we first did, that much hard and persevering work will be necessary before any of the benefits of atomic energy will be really ours.

During the period of abundance of the sources of energy which are now in use there will be two ways in which atomic energy can prove its significance. It may compete with our current sources of fossil energy and, second, it may open up new fields. As to the

Real success will therefore come to atomic energy in the near future only on the second path—by the discovery of new needs which atomic energy is able to satisfy better than existing sources can, by opening up new possibilities which it would be difficult or even impossible to realize with the sources of energy which are now in use. This task atomic energy has not yet achieved or even tackled. In fact, research on nuclear energy has to be so sheltered and separated from other industrial and economic problems that it will require extraordinarily keen vision to discover those needs which it is particularly suited to satisfy.

Some time hence, when the currently used sources of energy will near exhaustion, the situation will be different. Then nuclear energy may become the savior of our abundant life. But even then, nuclear

TABLE 1

Source	Coal	Oil	Atomic energy	Solar energy
Energy available in U.S.A. 10^{15} kcal	18,000	25 high-grade 300 low-grade	100 high-grade ores 3×10^{10} very low-grade ores and rocks	20,000 per year
Consumption per year	3.6	2.5 high-grade 0.5 low-grade	?	
Investment per/kw power plant	\$110		\$250	
Investment for producing 1 kjoule fuel/sec		\$110 from high-grade \$150 from low-grade sources		

former, our industrial and even our everyday life has adapted itself to the possibilities of chemical fuels to a degree of which we are rarely conscious. The transition to a new source of energy would involve a re-orientation of many methods of manufacturing and also cause a shift in the character of many of the commodities and services which industry can make available. It will not be easy, therefore, for atomic energy to woo away very much territory from the chemical fuels in the near future. Even if it did, its success along this line would be quite comparable with the success of the turbine—which is great, but not decisive for the over-all economic or social life.

"Atomic Energy" was one of the addresses delivered at the Symposium on Sources of Energy, held in Washington, D. C., on September 15, during the Centennial Celebration of the AAAS.

energy will not be the only one in the field; it will have to compete at least with solar energy, of which there is an immense abundance.

Table 1,¹ which I am sure you have seen before in this or another form but the contents of which are well

¹ The following publications were used to obtain the figures of Table 1: (a) "Geochemische Verteilungsgesetze der Elemente," by V. M. Goldschmidt. Norske Videnskaps Akademi i Oslo, Mat. Naturv. Klasse, 1937; (b) "Power and Fuel Data," by Gale Young, December 1945 (unpublished); (c) "Nuclear Power," Scientific Information Transmitted to the United Nations Atomic Energy Commission by the United States Representative, Vol. IV, September 1946 (by C. A. Thomas, et al.). Also "Non-Military Uses of Atomic Energy," by C. A. Thomas. *Chem. eng. News*, 1946, **24**, 2480, and "Atomic Energy: Its Future in Power Production," by J. B. Condliffe, et al. *Chem. Eng.*, 1946, **53**, 125; (d) "The New Power," by Gale Young. Chap. 4 in *One world or none*. New York: McGraw-Hill, 1946; (e) "Natural Gas, Coal, Oil Shale as Sources of Liquid Fuels," by E. V. Murphree. *Oil and Gas J.*, April 1948.

kept in mind, illustrates this situation. It gives, for the different energy resources—coal, oil, atomic energy, and sunshine—the magnitude of the reserves and the yearly consumption. With respect to coal we have enough for 5,000 years at the present consumption. The situation with respect to oil is more precarious. As to atomic energy, you see that there is not too much of it in the form of high-grade ores. The supply in low-grade ores is practically inexhaustible. The magnitude of the solar energy is obviously great.

There are three points in Table 1 which I want to emphasize particularly. First, the total amount of coal under the ground in the United States has somewhat less heat content than the United States receives as sunshine during a single year. The over-all situation for the whole earth is even worse. Paradoxical as it may sound, the sunshine which falls on an acre of land during a single year would have, in the form of coal, a value of about \$5,000. Second, if we look a little further ahead than a few hundred years, the chemical sources of energy are surely insufficient, and some of the new sources of energy will have to be utilized. Only two such sources are now known: nuclear energy from low-grade ores and solar energy. The question to which of these belongs the future will probably be decided by the relative convenience with which these two sources of power can be utilized and by the magnitude of the effort needed to exploit low-grade ores, on the one hand, and to concentrate solar energy, on the other. The last point which I wish to make is that oil or gasoline consumption is, in spite of the higher price of this fuel, almost as great as that of coal. This shows that the price of fuel is not always the decisive consideration; its adaptability and concentration are often more important.

The figures of our table clearly show that coal and oil cannot remain very long the predominant fuels. Nuclear energy may eventually replace them, but the above figures do not do more than to leave this possibility open. As for the present, a number of independent studies show, first, that nuclear energy is on the verge of competing with coal and, second, that a cheapening of power may have a stimulating influence on our economy, which could go far beyond the direct benefits calculable on a dollar-and-cent basis. The stimulating influence on more backward countries may be even greater.²

² Cf. in particular the Special Papers of the Cowles Commission, "Nuclear Fission as a Source of Power," by John R. Menke, and "Economic Aspects of Atomic Power," by Jacob Marschak, Sam H. Schurr, and Phillip Sporn. Chicago: Univ. Chicago Press, 1947. Also, "Some Economic Implications of Atomic Energy," by Walter Isard. *Quart. J. Econ.*, 1948, 72, 202. I am also personally indebted to Prof. Marschak, Dr. Schurr, and their collaborators for communicating to me a vast amount of unpublished material.

My personal impression would be that the emphasis on the stimulation of economic life is perhaps somewhat exaggerated. A similar and even more intense stimulation could be expected from the easier availability of many other types of goods—for instance, ingredients of housing. On the other hand, it seems to me that most price estimates disregard the ability of a stationary power plant, which uses the raw materials uranium and thorium not only to furnish heat and electricity but also to manufacture a pure fissionable material which is bound to occupy the role of a high-grade fuel (such as gasoline). The investment cost for nuclear energy, given in the last row, which militates so strongly against the economic attractiveness of nuclear energy, should be compared, therefore, not with the investment cost of a stationary power plant but with the joint investment costs of a power plant plus an oil refinery. This would improve considerably the economic attractiveness of atomic energy, while the first point I made would tend to decrease the importance of energy sources in general for our present economy. Perhaps even more important than these factors, which can be reduced to a dollar-and-cent basis, will be the relative convenience and safety with which the different types of plants can be operated. The full impact of the enormously dangerous radioactivity accompanying all nuclear energy operations is being felt increasingly, and the need of training a large number of people in new techniques involves an additional investment, the magnitude of which is difficult to estimate.

Let me now go over somewhat to the technical side, and, although this has been done on many occasions before, describe once more the broad features of the arrangements in which uranium can be used for the generation of energy.

Just as a single log cannot burn in our fireplace, in a similar way there is a minimum amount of uranium which is necessary to produce power. This minimum amount is called the critical amount. Once this critical amount is assembled in the so-called reactor space, it undergoes fission, and the energy of the fission fragments is converted into heat. This heat can be transferred by means of a heat transfer medium, which circulates through the reactor space, to a conventional heat engine.

Nothing could be simpler in principle than this, and there are only two problems which are not encountered in conventional engineering. These are the limitations of the heat transfer medium to substances which do not stop the chain reaction and the need to surround most of the equipment with a tight and thick shield. This shield has to protect the environment from the deadly radiation of the reactor and of the

heat transfer medium which becomes radioactive within it.

The energy which can be liberated from uranium is about 3,000,000 times greater than that contained in the same mass of coal. The ratio is 10,000,000 if we add to the weight of coal the weight of oxygen which it needs for burning. This establishes the most im-

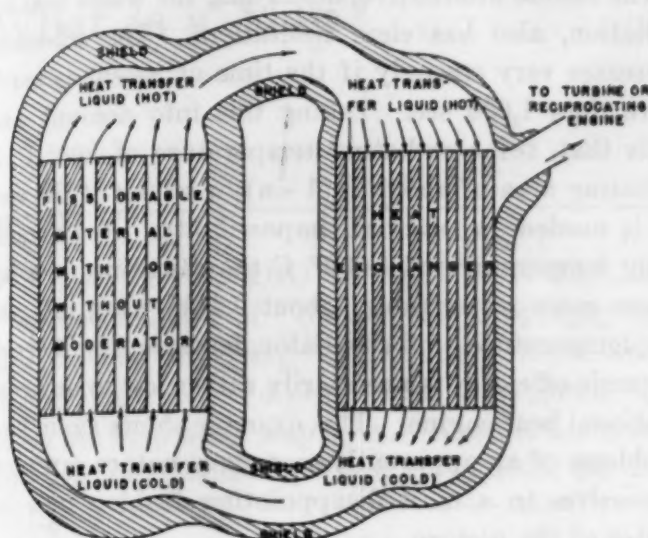


FIG. 1

portant characteristic of uranium as a fuel: it is practically weightless. This is, of course, not true of the whole power-generating equipment. In particular, the weight of the shield in many, if not most, cases overbalances the saving in fuel weight. This is particularly true in small engines and when refueling is easy. A serious disadvantage of the nuclear fuel is, furthermore, that any accident which breaks the shield is likely to liberate a vast amount of radioactivity and thus develop into a calamity much beyond the calamity which may result from an accident in the operation of the conventional sources of power.

Primarily, nuclear energy appears as the kinetic energy of fission fragments. The velocity of these corresponds to a temperature of about 600,000,000,000° C, and one feels that it is a pity to degrade this high temperature to a pittance of a couple of thousand degrees. For this reason, a good deal of thought has been spent on methods for a direct utilization of the energy of fission. Electric, electromagnetic, thermoelectric, and chemical methods have been discussed in some detail.³ To date, none of these methods has proved attractive, and it is at least temporarily conceded that the fission energy will have to be converted into heat at a tractable temperature before it is further utilized. For land-based power plants, in which the rejected heat can be easily discarded at a few hun-

³ Much of the material referred to remains unpublished. Cf., however, Marschak, Schurr, and Sporn, footnote 2.

dred degrees, this is not a major disadvantage, since the efficiency in this case is already close to its optimal value if the prime heat is delivered above 1,000°. However, the need for converting the energy of the fission fragments into heat becomes more of a drawback if one tries to exploit the most outstanding feature of nuclear energy—its enormous concentration.

Figs. 1 and 2 show the by now conventional arrangements to generate power and thus illustrate what I have previously called the competitive uses of nuclear energy. In the arrangement of Fig. 1 the heat transfer medium first traverses the fissionable material through a number of channels, gathering up the heat generated, and then flows to a heat exchanger. In this heat exchanger the heat of the primary coolant is transferred to another medium which, in its turn drives a turbine or a reciprocating engine. In the arrangement of Fig. 2 the primary coolant drives the turbine directly. This arrangement has fewer parts, but a larger shield than the former, and a turbine which is,

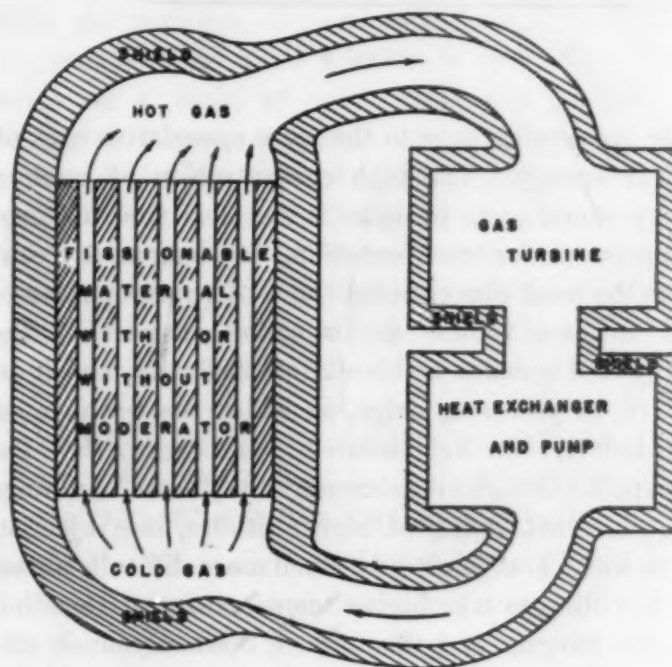


FIG. 2

because of the radioactivity of the primary coolant, inaccessible. It is not yet possible to say with certainty which of the two arrangements is more advantageous and under what conditions.

The time scale for the development of nuclear energy on a substantial scale naturally comes up at this point, but it is a question most difficult to answer. Our uncertainty concerning this point not only has its origin in our inability to answer several technical and scientific questions, but is caused, to an equal degree, by the circumstance that the answer is bound to depend on the strength of our desire to see nuclear energy prove itself soon, on our courage, and on our confidence in our technical judgment and foresight.

In other words, the human element strongly enters the picture.

Disregarding this human element, M. H. L. Pryce gave a tentative answer in a most thoughtful article in a recent issue of the *Bulletin of Atomic Scientists* (1948, 4, 245). He estimates that nuclear energy may begin to replace coal in about 30 years. The number 30 is uncertain, but it is not likely to be less than 5 or more than a few hundred.

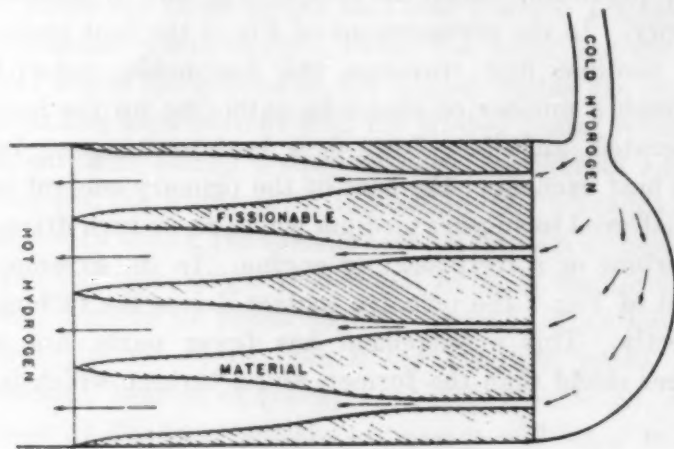


FIG. 3

Let me now go over to the more speculative uses of nuclear energy. The high concentration of nuclear energy would seem to make it the ideal fuel for providing power for transportation. As long as one considers the most conventional types of transportation—land and sea routes—the rejection of part of the energy still remains a subordinate difficulty, and it is, in fact, in powering ships, in which the problem of radioactivity can be mastered more easily, that the first application of nuclear energy may come. In long-range aircraft, flying at high altitudes, the rejection of the waste heat is already much more difficult, unless one is willing to take higher temperatures of rejection into the bargain and thus reduce thermodynamic efficiency. If one considers, finally, travel outside the gravitational sphere of the earth, the problem of the rejection of waste heat becomes dominant.

In order to escape the gravitational field of the earth, one needs about 15,000 kcal/kg of escaping material. Since the energy content of a fissionable material is more than 1,000,000 times greater than this, the energy requirement is not, in itself, prohibitive even if one assumes a relatively low efficiency, η , for the process which furnishes the needed energy. However, for an efficiency, η , the waste heat amounts to $15,000 (1 - \eta) / \eta$ kcal/kg, and unless one can dispose of this, it will surely vaporize the body of the ship. As we discussed it before, the problem of elimination of the waste heat can easily be solved on the sea; it can also be solved in the air, but if the ship

is to have power also outside the atmosphere, it can keep cool only either by throwing off hot parts or by radiation. The first alternative is the one which is discussed most commonly,⁴ but it has its definite limitations. Current opinion is that it may be barely sufficient to achieve the purpose: to raise a rocket off our planet. What runs out first is, characteristically, not the energy of the uranium but the hydrogen.

The second alternative, discarding the waste heat by radiation, also has clear limitations. The efficiency decreases very strongly if the time of ascent is much more than 1,000 sec. Taking this into account, one finds that, for a radiating temperature of 200° C, a radiating area of about $20(1 - \eta) / \eta$ m²/kg of the vessel is needed—a practical impossibility. For a radiating temperature of 1,000° C the radiating area becomes more manageable: about $0.4(1 - \eta) / \eta$ m². At this temperature of the radiator, however, the thermodynamic efficiency is necessarily rather low in any conventional heat engine. This example shows again how problems of an apparently secondary nature can push themselves in a most disappointing fashion into the center of the picture.

Breaking the gravitational prison of the earth is so challenging a problem that I wanted to say a few words about it, even though it would be clearly premature to discuss it in detail. Furthermore, it is not the direction in which nuclear energy has so far proved itself most decisively. That field is indeed an application of nuclear energy in which a new need has been discovered. It is the procurement of research facilities for biology, chemistry, and physics by radioactive tracers, by new and more intense types of radiation. Even though this subject is the last one on my list, it is at present the most important one, and it is quite possible that it will maintain this position for a long time. The subject, which has received adequate treatment on several occasions,⁵ lies outside the scope of our symposium. If we could divest ourselves from our admiration of the spectacular, we might easily find that the nuclear research facilities are for the present more important than nuclear energy. The success of the research which they support is a more real and more truly human need than is the need for additional energy and power.

However, there is good reason to look forward with confidence also to the more direct applications of nuclear energy. In order to be fully successful, these

⁴ Cf. e.g. "Atomic Power for Airplanes and Rockets" article in the March 1947 issue of *Atomic Information* based on L. Alvarez's address.

⁵ See, for example, (a) *Radioactive tracers in biology*, by M. D. Kamen. New York: Academic Press, 1947; (b) *The use of isotopes in medicine and biology* (Symposium Report). Madison: Univ. Wisconsin Press, 1948; (c) various articles in *Nucleonics*, 1948.

applications will require more of the undeviating interest which is so necessary for technical success but not enough of which they have received so far. They will surely receive this interest in the future, and we may hope that they will receive it from us—not only from our neighbors and children. And we may even

dare to hope that the success may be so overwhelming that the first application of nuclear energy will appear just as insignificant, in comparison, as the first and still most efficient heat engine, the cannon, is in comparison with our generators of electricity and industrial power.

What Is a Map?

Eugene Van Cleaf
The Ohio State University

SOME YEARS AGO ISAIAH BOWMAN, in a consideration of "Commercial Geography as a Science" involving "Reflections on Some Recent Books," propounded a conundrum as follows: "Q.—When is a map not a map? A.—When it has neither scale nor coordinates" (*Geogr. Rev.*, 1925, 15, 285–294).

In the light of a regenerated interest in maps among both geographers and the general public, Dr. Bowman's comment has added significance today. Here and there American geographers, consciously or unconsciously, have exhibited a fault common in British circles—failure to provide either scale or coordinates, or both, for drawings which they designate as maps. There may be justification for a portrayal of a portion of the earth's surface without scale or coordinates on the grounds that the objective is not the orientation of any part of it with respect to the earth, but rather a presentation of a chart which will reveal certain general relationships within the limits of the area shown. For example, one might draw a sketch to show a road pattern or a succession of stream meanders, not with the idea of enabling the reader to measure distances or to determine the location of the respective elements upon the earth's surface, but rather for purposes of exhibiting certain characteristics of the phenomenon itself, irrespective of its relation to the earth. Such diagrams may serve their purposes admirably, but, lacking scale or coordinates, they hardly reflect the fundamental basis of a map; hence, they are not entitled to the designation *map*. If an individual wishes to apply the term *map* to these various drawings because that word is more convenient or more appealing than another but recognizes the incorrectness of so doing, he can protect himself by indicating his deliberate substitution to be a matter of convenience. This type of action can be illustrated in the case of the reciprocal use by some persons of the names Russia and USSR.

They announce the fact that they mean the USSR whenever they say "Russia."

It may be trite to record the fact that man from very early times has been interested in making a graphic recording of the surface features of the earth. He recognized time and distance, and long struggled with the problem of measuring them. He was intrigued, first, by their relation to the nature of the earth as a body of some kind upon which man struggled for an existence and to the earth as a planetary body. Not long after he ventured out of sight of land or traversed considerable distances overland, he was moved to find safer ways of travel than dead reckoning or the marking of fixed reference points as momentary guide posts. As is now familiar to all of us, he ultimately solved many of these perplexing problems as he accumulated factual data relative to the nature of the earth itself, the characteristics of the solar system, and the universe in general.

Some geographers argue that many early representations of the earth showed neither scale nor coordinates yet have been designated as maps. The use of the term *map* in these instances, however, has probably been "complimentary," in the sense that the ignorance of the times was no fault of the peoples and that, had there been an adequate knowledge of the sphericity of the earth and of the measurement of distance, the fundamentals of scale and coordinates would have been brought into play. The ancients did ultimately lay the foundation for the assignment of 360° to a circle and the use of heavenly bodies to fix places upon the earth. Eratosthenes (about 275–196 B. C.) succeeded in securing some such data as we now demand as essential characteristics of maps, and used them. Ptolemy (90–168 A. D.) did likewise, but there were others who did not, either because they were unfamiliar with the work of their predecessors or had no confidence in their mathematical philosophies. The significance of the map for measurement

purposes was well put by Eckert (*Bull. Amer. geogr. Soc.*, 1908, 40, 344-351) when he said:

To test the quality of a map is to determine how well it has solved the geometric problem imposed upon it of reproducing constructively the distribution in space of geographic objects. Due allowance should be made . . . for the scale and purpose of the map as these determined the number and extent of geographic features to be represented on it.

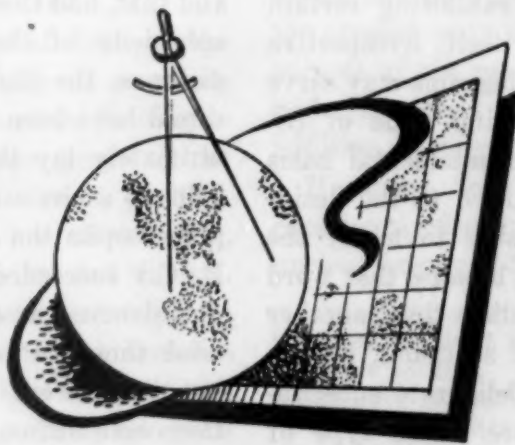
Eckert also gives emphasis to Hermann Wagner's attitude toward maps when he states that "one of the principal domains of geography is that of measuring. Measurements are in many cases best made on maps."

Geographers agree that a map is a graphic representation upon a plane of the earth's surface or some part of it for purposes of enabling a reader to orient himself with respect to certain characteristics or areas of the earth. As such, it is a mathematical expression revealing distances, areal dimensions, locations, and directions. Perhaps the latter statement is redundant, for a draftsman producing a map must employ scale and coordinates to do so, and accordingly a map automatically offers the data just cited. *How* we use a map, of course, is not open to prediction, nor does it detract from the definition of the term *map*.

There are geographers who say that some drawings are merely "sketch maps" intended only to illustrate a few local relationships and that their mathematical aspects are unnecessary in the particular situation. If this be so, then the portrayal under consideration should not be described as a map but rather as a diagram or perhaps a chart. When neither scale nor coordinates are shown, about the best we can say for a drawing intended to represent some portion of the earth's surface is that it "floats." Although the earth as a planet may "float" in space, certainly its parts are not independent; all are integrated to con-

stitute the whole body. The absence of coordinates seems to imply that the author of the so-called map expects the reader to provide such orienting facilities out of his memory or his possible personal familiarity with the area. For example, as these words are being recorded the writer is looking at a "map," in an excellent book, which shows the distribution of oil fields in the Caribbean region. There are no coordinates, and there is no scale. The distribution of the data delineates a pattern within the area, and if that is what the authors wish to reveal, the objective is attained. But for the reader who might care to determine distances between fields, or distances in relation to other areas of the drawing, that is impossible. Neither can the reader determine the latitude or longitude of any position in the area. Surely this drawing floats.

The indifference of some geographers to the revelation of scale and coordinates as indispensable parts of maps and in some instances their aggressiveness in arguing for the omission of these essentials is difficult to appreciate. If geography is entitled to be classified as a science, then surely a major quality must include the element of measurement. Although a map in itself is not geography, but rather a mathematical expression, there seems to be general agreement among geographers that it is basic to the science. Accordingly, it would appear that geographers cannot condone the application of the term "map" to a drawing that does not reveal at least one set of coordinates with scale or, if scale be omitted, sufficient sets of coordinates to make possible the calculation of scale. They should not tolerate as an instrument of their science any presentation purporting to be a map which does not incorporate coordinates and in most circumstances, scale as well, unless some satisfactory explanation is made for the omission.



NEWS and Notes

Saul B. Sells, formerly assistant director, Consumers' Goods Price Division, and chief statistician with the Statistical Standards Division, OPA, has joined the staff of the Department of Psychology, USAF School of Aviation Medicine, Randolph Field, Texas.

Morrrough P. O'Brien, dean of the College of Engineering, University of California, has returned to the Berkeley campus after a year's leave of absence spent in private industry. While on leave he served as director of research and engineering for the Air Reduction Company.

Mont A. Cazier, chairman of the Department of Insects and Spiders, American Museum of Natural History, has recently returned from a 21,000-mile trip through the United States which has yielded the largest single collection of tiger beetles in history. The tiger beetle, which feeds exclusively on other forms of animal life, thrives in every known region in the world and, in adapting itself to varied environmental conditions, undergoes remarkable bodily changes. Dr. Cazier's collection of more than 15,000 individual specimens includes 6 entirely new subspecies.

Leigh C. Anderson has been named chairman of the Department of Chemistry at the University of Michigan to succeed **C. S. Schoepfle**, who requested relief from his position because of illness.

Emanuel Maxwell, who since 1941 has been on the staff of Massachusetts Institute of Technology, where he has been carrying on investigations in the microwave field, is now with the Cryogenics Section at the National Bureau of Standards. At the Bureau he will be concerned with low-temperature physics and superconductivity.

Edward D. DeLamater has joined the staff of the Department of Dermatology and Syphilology, University of

Pennsylvania, as associate research professor. He will act as director of research in the Department and will also develop a Mycology Laboratory.

Edward C. Johnson, of the State College of Washington, will become dean emeritus of the College of Agriculture and director emeritus of the Washington Agricultural Experiment Stations on January 1. On that date, he will have completed 30 years as dean of Agriculture, during which time he also served as director of the experiment stations for 27 years, a post he relinquished in January 1946. **Stanley P. Swenson**, chairman of the Department and Division of Agronomy, will become the new dean of the College of Agriculture.

Paul Edmund Hering, formerly of Carthage College, has joined the faculty of Southwestern Institute of Technology, Weatherford, Oklahoma, as professor of pharmacology.

Visitors to U. S.

Otto H. Warburg, whose arrival in this country was reported in *Science* (July 30, p. 101), is pictured on this week's cover in his laboratory at the University of Illinois. The famous German biochemist and Nobel Prize winner is visiting professor at the University during 1948-49.

R. P. Van de Kastele, president of N. V. Technisch Chemisch Adviesbureau, i.o., Eindhoven, Netherlands, is in the United States until early in December. He can be reached in care of the U. S. associated firm, Foster D. Snell, Inc., 29 West 15th Street, New York 11, New York.

Grants and Awards

Nobel Prizes for 1948, amounting to about \$44,000 each, have recently been awarded to: **P. M. S. Blackett**, Langworthy professor of physics at Manchester University since 1937, for his improvements of the Wilson cloud chamber and his discoveries in the field of cosmic rays; **Arne Tiselius**, professor at Uppsala University, for his biochemical discoveries and his invention of laboratory apparatus used widely for the separation of proteins;

and **Paul Mueller**, of Basle, Switzerland, in the field of medicine, for his discovery of the insect-killing powers of DDT. Dr. Mueller is affiliated with the Geigy Drug Industries.

Harold F. Sherwood, of the Kodak Research Laboratories, received the Rodman Medal at the recent 93rd Annual International Exhibition of the Royal Photographic Society, held in London. The medal, named after George H. Rodman, a pioneer in radiography, is awarded for outstanding work in photomicrography, radiography, and other scientific fields. Mr. Sherwood's prize-winning exhibit, "Microradiographs of Thin Sections of Metal, Wood, and Paper," is the first American entry to be selected for this honor since the award was established in 1935.

I. M. Kolthoff, head of the Division of Analytical Chemistry, University of Minnesota, has been selected to receive the William H. Nichols Medal of the New York Section of the American Chemical Society for 1949. The Nichols Medal, one of the highest honors in chemical science, goes to Prof. Kolthoff for his world leadership in the development of modern analytical chemistry. Presentation of the medal will be made at a joint meeting of the New York Section, American Chemical Society, and the American Section, Society of Chemical Industry, at the Hotel Pennsylvania on March 11, 1949.

J. Edward Vivian, associate professor of chemical engineering at Massachusetts Institute of Technology, and **Roy P. Whitney**, research associate at the Institute of Paper Chemistry, have been chosen to receive the Junior Award of the American Institute of Chemical Engineers for their work on the absorption of chlorine in water. Presentation of the award took place at a special Awards Dinner held in conjunction with the annual meeting of the American Institute of Chemical Engineers in New York City, November 7-10.

The Frank Forrest Award for the best technical paper on glass published in this country during 1947 was presented to **Howard R. Swift**, of the Research Department of Libbey-Owens-Ford Glass Company, at the

recent meeting of the Glass Division of the American Ceramic Society held in Bedford Springs, Pennsylvania. In addition to carrying with it considerable prestige in the industry, the award consists of \$100 in cash, the gift of the Preston Laboratories, Butler, Pennsylvania.

The College of Medicine, University of Illinois, has received a renewed grant of \$2,000 from Smith, Kline and French, of Philadelphia, in support of research on the effects of amines in experimental renal and other hypertension. The research will be conducted by E. A. Ohler, under the supervision of G. E. Wakerlin, head of the Department of Physiology.

Elmer D. Merrill, director emeritus of the Arnold Arboretum, Harvard University, has been made an Officer in the Netherlands Order of Orange Nassau in recognition of his contributions to the knowledge of the Malaysian flora, his stimulating interest in Dutch and Indonesian botany, and his efforts to promote international cooperation in botany. The award was made on October 28 in a ceremony at the Netherlands Consulate in Boston in the presence of Mrs. Merrill and Frans Verdoorn, who represented the biological institutions of the Netherlands Indies.

Fellowships

The Lalor Foundation Fellowship Program at the Marine Biological Laboratory, inaugurated in 1947, will continue in 1949. Postdoctoral summer fellowships in the fields of biophysics, biochemistry, and physiological chemistry will be available. The fellowships are designed primarily to aid promising young investigators who can make maximum use of the facilities and opportunities provided at the Laboratory. In addition to laboratory facilities, the grants are intended to cover approximately the living expenses of the investigators at Woods Hole and necessary traveling expenses to and from Woods Hole. The committee administering the fellowships consists of Eric Ball, Kenneth Cole (chairman), Daniel Mazia, Charles Packard, and A. K. Parpart. Inquiries and applications should be addressed to the director of the Marine

Biological Laboratory, Woods Hole, Massachusetts, and applications should be received by December 31, 1948.

Colleges and Universities

The Graduate School, Agricultural and Mechanical College of Texas, recently announced the lecturers for its 1948-49 series. James B. Sumner, of Cornell University, spoke on November 3, on "The Relationship of Enzymes to Life." Others who will speak at the College include Sumner T. Pike, of the Atomic Energy Commission, December 6; Hugh L. Dryden, director of aeronautical research for the NACA, February 28; M. King Hubbert, associate director of exploration and production research, Shell Oil Company, who will speak sometime in March; and E. C. Stakman, chief of the Division of Plant Pathology and Botany, University of Minnesota, whose lecture will be given sometime during March or April.

Wayne University has announced the addition of four assistant professors to its Chemistry Department staff: James S. Fritz, formerly of the University of Illinois; Karl H. Gayer, a lecturer in chemistry at Ohio State since 1944; Calvin L. Stevens, who recently held a postgraduate fellowship at Massachusetts Institute of Technology; and Dan Trivich, who has been on the staff of the United Chromium Company.

The new Yale Child Study Center, which will include the Yale Clinic of Child Development established by Arnold Gesell, who retired as professor of child hygiene and director of the Clinic on July 1, will have as its director Milton J. E. Senn, formerly director of the Institute of Child Development and professor of pediatrics and psychiatry at Cornell University Medical College. In addition to a guidance nursery and film library, the Center will provide clinical resources for students from professional disciplines interested in the growth, development, behavior, and personality of human beings. Facilities for graduate work and research will also be expanded. Dr. Senn, who will be Sterling professor of pediatrics and psychiatry, has pioneered in emphasizing the relationship between these two fields.

Dr. Gesell, author of a number of well-known volumes on child psychology and growth, will continue his research at the University and will direct a Child Vision Project supported by a grant from the American Optical Company. Work on child vision has been carried on for the past four years as a part of the general program of the Child Development Clinic.

The Arthur Dehon Little Memorial Lectureship, established in 1944 at Massachusetts Institute of Technology with funds donated by Arthur D. Little, Inc., in memory of its founder, but not inaugurated until 1946, when the speaker was Sir Edward Appleton, followed last year by J. Robert Oppenheimer, will be continued this year, with Robert E. Wilson as the lecturer. Dr. Wilson, chairman of the Board of the Standard Oil Company of Indiana, whose topic will be "Research on a Single Reaction and Its Social Effects," is a graduate of M. I. T. and former director of the Research Laboratory of Applied Chemistry there. The lecture will be given in Walker Memorial on November 23 at 8:30 P. M.

Meetings and Elections

The Florida Academy of Science will hold its annual meeting November 19-20 at the University of Miami, Coral Gables, Florida. Papers will be presented on various phases of the biological, physical, and sociological sciences, and field trips are planned to marine habitats and the new Everglades National Park. H. H. Sheldahl of the University of Miami, is acting as chairman of the Committee on Arrangements.

The American Mathematical Society announces three forthcoming meetings: November 26-27 at the Museum of Science and Industry, Chicago; November 27 at the University of California, Los Angeles; and December 28-30, the 55th annual meeting, scheduled for Columbus, Ohio, at the Ohio State University. Invited speakers at the Chicago meeting will include P. R. Halmos and Saunders MacLane, both of the University of Chicago, who will speak on "Measurable Transformations" and "Dualities for Groups," respectively. At the Los Angeles meeting, Herbert Busemann

the University of Southern California, will deliver an address on "The Geometry of Finsler Spaces." Hermann Weyl, of the Institute for Advanced Study, will deliver the 22nd Isaiah Willard Gibbs Lecture at the Columbus meeting; Prof. Weyl's topic will be "Ramifications, Old and New, of the Eigen-Value Problem." Invitation speakers and their topics will include: A. S. Besicovitch, of Cambridge University and the University of Pennsylvania, "Parametric Surfaces"; Lamberto Cesari, of the University of Bologna, the Institute for Advanced Study, and Ohio State University, "Area and Representation of Surfaces"; and Mark Kac, Cornell University, "Probability Methods in Some Problems of Analysis and Theory of Numbers." Following the presentation of the Bôcher Memorial Prize, Linus Hille, of Yale University, president of the Society, will deliver the presidential address entitled "Lie Theory of Semigroups of Linear Transformations."

The 1948 national convention of the Society of The Sigma Xi will be held in the Hotel Cleveland, Cleveland, Ohio, November 26-27. At the opening session on Friday evening, Carl D. Anderson, of the California Institute of Technology, Bradley M. Hatten, of the University of Michigan, and Arnold Gesell, of Yale University, will speak and show films. J. W. Mark, president of Research Corporation, will act as chairman.

On Saturday afternoon, November 27, following the Sigma Xi Convention, the first convention of RESA, the Scientific Research Society of America, will be held.

The Gerontological Society will hold its annual scientific meeting January 8-9 at the Hotel Commodore, New York City. Correspondence on scientific papers should be addressed to Nathan W. Shock, City Hospital, Baltimore 24, Maryland.

The fourth annual Analytical Symposium, sponsored by the Analytical Division, Pittsburgh Section of the American Chemical Society, will be held at the Hotel William Penn on January 20-21. An innovation of the symposium will be a comprehensive

exposition of new analytical tools. D. P. Bartell, chief chemist of the Allegheny Ludlum Steel Corporation, Brackenridge, Pennsylvania, will be chairman.

The newly formed Utah Chapter of the American Society for Metals is the 77th chapter to join the national organization. More than 100 people attended the initial organization meeting at which W. C. Dyer, of the Geneva Steel Company, was elected chairman; Don Rosenblatt, of the American Foundry & Machine Company, vice-chairman; and H. E. Flanders, professor of metallurgy at the University of Utah, secretary-treasurer.

NRC News

The Food and Nutrition Board held its 33rd meeting in the National Academy of Sciences Building in Washington, October 29-30, with Frank G. Boudreau presiding. Featured speakers included Norman Wright, of England, current adviser on nutrition to the Ministry of Health, and Major Gen. H. M. Whitty, who is in charge of feeding the British Army.

Duncan Wall gave the Board a preview of the forthcoming FAO Conference, to be held in Washington beginning November 15.

At a dinner meeting in the Mayflower Hotel, James McGrath, of the Newfoundland Department of Health and Welfare, spoke on nutrition conditions in Newfoundland observed as the result of Nutrition Surveys made by a group of U. S. physicians and nutritionists during 1944 and again in 1948.

Special subjects of public interest considered by the Board during these sessions included: (1) recommendations to be made by the Board's representative in the forthcoming FSA hearings on definitions and standards for bread; (2) modification of the Food, Drug, and Cosmetic Act to the effect that chemicals added to foods during processing should undergo the same rigid tests for nontoxicity as are applied to new drugs, and that their addition should improve rather than lessen the nutritional quality of the food product. A special Committee on Food Protection was appointed to survey this situation; (3) provision of

additional calcium in U. S. diets; (4) proposal and approval by the Board of establishment of a committee to study anthropometric standards of height-weight in relation to nutritional requirements.

The Board approved and has ready for publication monographs on dental caries, clinical nutrition, and nutrition surveys. It adopted a resolution favoring Federal legislation requiring the iodization of all table salt.

Finally, the Board prepared a statement, to be released in connection with the FAO Conference, on the food situation as of November 1948, with recommendation of measures to alleviate current food shortages and provide for future exigencies in relation to prevailing economic conditions.

Deaths

Robert Tracy Jackson, 87, paleontologist and former curator of fossil echinoderms at the Museum of Comparative Zoology, Harvard University, died October 24 at his Peterborough, New Hampshire, home.

Charles Morley Wenyon, 70, authority on tropical medicine and distinguished protozoologist, died October 24 at his London, England, home. Author of the standard work, *Protozoology*, Dr. Wenyon was for many years associated with the Wellcome Research Institution and Foundation, variously holding the positions of director of research in the tropics, director-in-chief of the Wellcome Bureau of Scientific Research, director of the Research Institution, and, finally, director of research in the Wellcome Foundation.

Charles E. Bonine, 74, widely-known consulting engineer and former associate director of the Franklin Institute, died in Chestnut Hill Hospital, Philadelphia, on October 25. Early in his career Mr. Bonine had originated processes for the textile, chemical, and metal industries and was one of the first designers of a motor starter for automobiles.

Wesley Clair Mitchell, 74, internationally known authority on economics, died October 29 in the New York Hospital, New York City, after a brief illness. Member of the research staff

of the National Bureau of Economic Research, as well as its director for many years, and professor emeritus of economics at Columbia University, Dr. Mitchell had also served as president of the AAAS in 1938.

A bibliography listing 255 atomic energy reports and supplementing a list issued earlier this year has just been released by the Office of Technical Services, Department of Commerce. This list (PB87782-S) and the February 1948 list (PB87782), including both American and British reports, are available from OTS for \$.50 and \$.75, respectively.

The world's first mobile betatron, a 10,000,000-volt X-ray generator the rays of which can penetrate 16 inches of steel, is being installed at the Naval Ordnance Laboratory, White Oak, Maryland. The GE-built machine is to be placed in operation sometime after the first of the year. The first industrial machine emitting rays which will penetrate steel thicker than 12 inches is also unique in that it may be aimed in any direction. With this powerful machine, which will be housed in a special building surrounded with 3-foot-thick reinforced concrete walls to insure protection of personnel, studies will be made of the complicated internal assemblies of mines, torpedoes, and other ordnance pieces of equipment.

A Seminar on High Polymers is currently being presented by the National Bureau of Standards, under the chairmanship of Robert Simha, Division of Organic and Fibrous Materials. Future lecture dates, titles, and speakers are as follows: January 6, "Rheological Properties of Polystyrene," R. S. Spencer, Dow Chemical Company; February 24, "Some Aspects of Dynamic Rubber-like Elasticity," A. W. Nolle, University of Texas; March 3, "Reactions of Free Radicals With Hydrocarbons," E. W. R. Steacie, National Research Council; April 7, "Variables Which Influence the Properties of Chemical Rubbers Prepared by Emulsion Polymerization," C. F. Fryling, Phillips Petroleum Company; and May 5, "The Chemistry of Some Derived Polymers of the Vinyl Series," W. O.

Kenyon, Eastman Kodak Company. The lectures are open to the public.

A Microbiological Institute has been established as part of an extensive realignment of the medical research program at the National Institutes of Health. Together with the Experimental Biology and Medicine Institute, established last December, the new unit will deal with research in such diseases as malaria, polio, typhus, and the common cold as well as basic research studies in physics, chemistry, nutrition, metabolism, and pathology. The new Institute will also do work in the establishment of standards for the safety, purity, and potency of sera, antitoxins, and vaccines for human use. Victor H. Haas will be the director of the new organization.

Make Plans for—

6th Annual Pittsburgh Conference on X-Ray and Electron Diffraction, November 19–20, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

American Physical Society, 288th meeting, November 26–27, University of Chicago, Chicago, Illinois.

American Mathematical Society, November 26–27, Chicago, Illinois.

American Society of Mechanical Engineers, 69th annual meeting, November 28–December 3, Hotel Pennsylvania, New York City.

Society of American Foresters, annual meeting, December 16–18, Statler Hotel, Boston, Massachusetts.

Recently Received:

The sugar molecule. A quarterly review of sugar research, available without charge from the Sugar Research Foundation, Inc., 52 Wall Street, New York City 5.

Non-self-governing territories: summaries and analysis of information transmitted to the Secretary-General during 1947. United Nations Publications; Sales No.: 1948, VIB, 1. Purchasable through International Documents Service, Columbia Univ. Press, \$4.00.

Science and Appliance. Published monthly except July and August by

the Ohio State University Research Foundation. (4 pp.)

The effectiveness of science teaching: a forum by the AAAS Cooperative Committee on the Teaching of Science and Mathematics (16 pp.). Recording available on loan basis from K. Lark-Horovitz, Department of Physics, Purdue University.

Announcer of scientific equipment (18 pp.). Available from Howe & French, Inc., Boston 10.

Statistical Bulletin of the Metropolitan Life Insurance Company, September 1948, featuring "Mortality of Medical Specialists."

L & N pneumatic control (Catalog ND4B, 1948), featuring Speedomax and Micromax. Available from Leeds & Northrop Company, 4934 Stenton Avenue, Philadelphia 44.

A record of pilchard eggs and larvae collected during surveys made in 1939 to 1941, by Elbert H. Ahlstrom. Fish and Wildlife Service Special Scientific Report No. 54.

The relation of patents to the anti-trust laws, by George E. Folk. Reprinted from "The Patent System: II," published as the Spring 1948 issue of *Law and Contemporary Problems*, Duke University Law School, Durham, North Carolina.

Nutrition Reviews, Vol. 6, No. 10, October 1948. Published monthly by The Nutrition Foundation, Inc., Chrysler Building, New York City.

Publications of the staff, October 1, 1946–February 29, 1948. Bulletin of the California Institute of Technology, Vol. 57, No. 2, June 1948.

Sci-en-tech news, October 1948. Published by the Chicago Technical Societies Council, 53 W. Jackson Boulevard, Chicago 4.

The anthracite forest region: a problem area, by F. A. Ineson and M. J. Ferree. (U. S. Dept. of Agriculture, Misc. Publ. 648.) Washington, D. C.: U. S. Government Printing Office, 1948. \$.40.

The National Health Council—what it is. Leaflet available from NHC, 1790 Broadway, New York City 19.

Monthly digest of technical papers (mimeographed; 5 pp.), issued by the U. S. Steel Corporation, 429 Fourth Avenue, Pittsburgh 19.

TECHNICAL PAPERS

A New Electroencephalogram Associated With Thinking

JOHN L. KENNEDY, ROBERT M. GOTTSANKER,
JOHN C. ARMINGTON, and FLORENCE E. GRAY

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In the course of experimentation on counting eye movements in reading by means of the corneoretinal potential (1), a 10-cycle/sec disturbance in the reading record was noted. Further investigation indicated that this disturbance was, in actuality, a new electroencephalogram. This paper will report certain interesting characteristics of the new EEG, which we shall call "kappa waves."

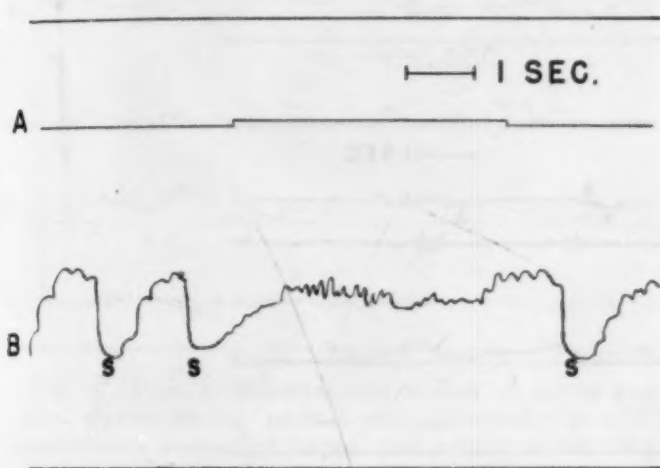


FIG. 1. Kappa bursts during reading.

Fig. 1 shows an electroculogram obtained while a subject was reading. The large potential changes at S are return sweeps from the end of a line to the beginning

duration of fixation on line A. The kappa waves (line B) appear most clearly during this period of fixation when the eyes are still. Close examination of the records obtained when the eyes are moving in reading shows that the waves are present but obscured by the activity of the eyes. From such records it has been found that kappa waves characteristically occur in intermittent, spindle-shaped bursts. They have an average frequency of 8-12 cycles/sec and an average amplitude of around 20 microvolts. The following studies have been conducted to find the circumstances producing kappa waves and the relation of these waves to other physiological phenomena.

The standard Grass 4-channel EEG apparatus was used in these studies. Filters of the power amplifiers were set to maximize the low frequencies. In addition, two accumulators (2) were employed to integrate (time constant, .2 sec) the 8- to 12-cycle/sec component of two of the channels. Two d-c amplifiers were used to record the integrated level of kappa and alpha waves as deviations from a base line. Electrodes were sponge-rubber tabs soaked in saline and glycerine solution (3). All records were made by means of the Grass ink writer on standard EEG recording paper.¹ Kappa waves were detected by electrodes placed just back of the external canthi of the eyes. The two ends of a metal headband, constructed from two bicycle clips, held these electrodes in place. When simultaneous occipital records (alpha) were taken, electrodes were placed under an elastic headband, about 2 cm above the inion and the same distance to the side. A ground electrode was attached to the subject's right cheek with adhesive tape. A similar electrode on the left cheek was used for the indifferent placement in the cases where monopolar records were taken from the right occiput.

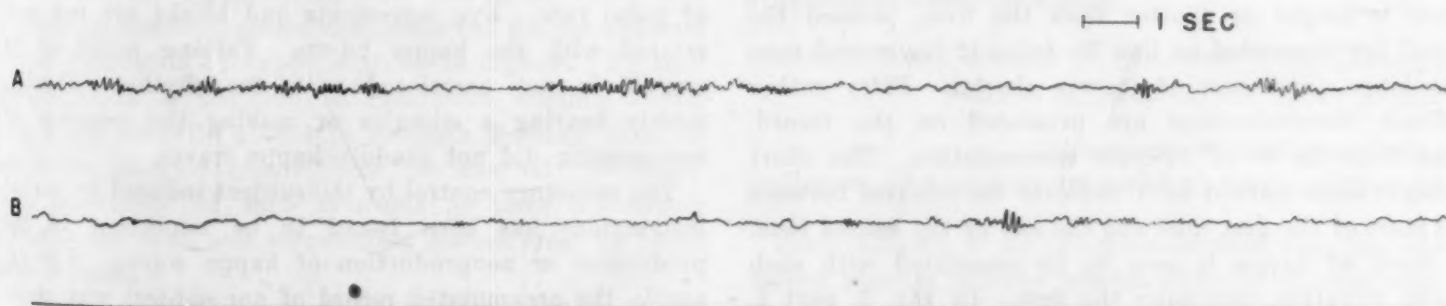


FIG. 2. Mental multiplication compared with "keeping the mind a blank."

of the next line. Successive saccadic movements are recorded as smaller, sudden potential changes. The steps in the record are fixations through the line of print. In the middle of the section of record, the subject fixated the first word of a new paragraph and signaled the

Several situations have been found which dependably produce kappa waves. One of these is mental arithmetic

¹ Tracings of sections of these records are presented as objective evidence. The original records are available for inspection by qualified investigators.

Fig. 2 is a composite tracing of two equivalent sections of record. Line A is the electroencephalogram taken from the canthal placement on a subject engaged in multiplying two-digit numbers (eyes fixated). Line B is a comparable record when the subject was attempting to "keep his mind a blank" (eyes fixated). The greater amount of kappa rhythm in mental multiplication is evident. Kappa intrudes occasionally when the subject is trying not to think. Introspective reports suggest that the intrusions of kappa correspond to "thoughts" during the period of attempted voluntary inhibition of thinking.

the upward deflection is the response of the subject. Line B is the canthal electroencephalogram and line C is the 8- to 12-cycle accumulation. Bursts of kappa waves are again seen to be associated with making decisions. Other situations which have been found to bring out a large amount of this rhythm are (1) learning tasks, such as nonsense syllables; (2) memory tasks, such as naming the 48 states; and (3) problem solving, such as that involved in mastering a finger maze. In general, kappa waves have been found to be most prevalent in situations which are usually classed as involving thinking.

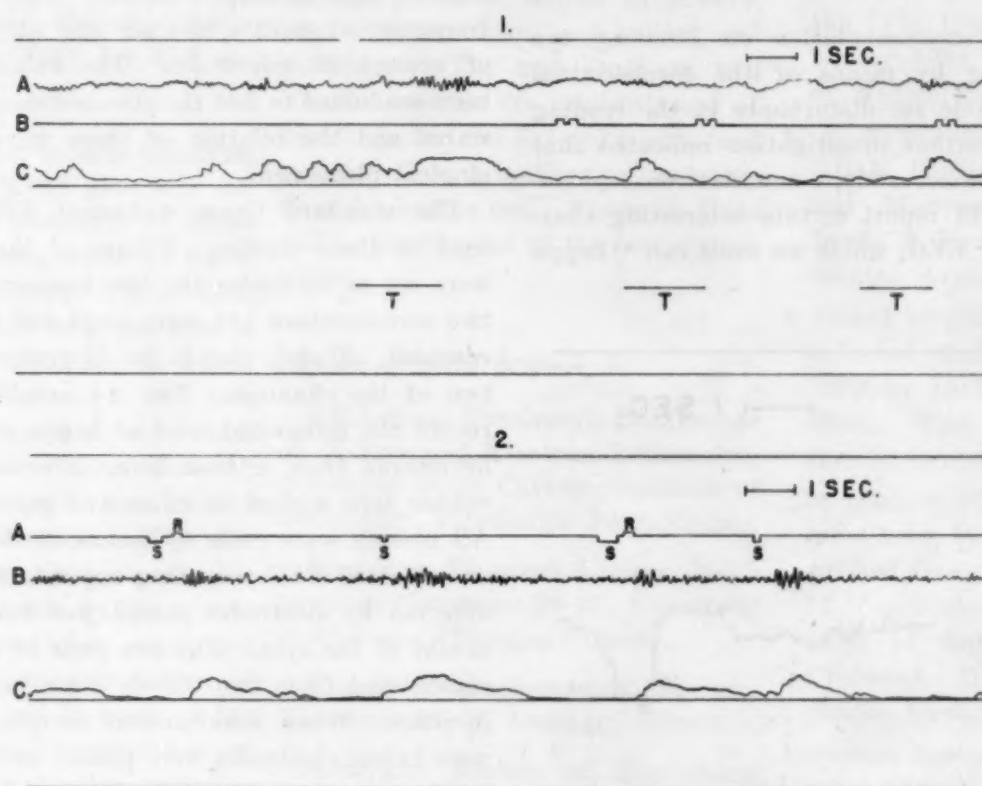


FIG. 3. Part 1, temporal discrimination (Seashore Record); Part 2, choice reaction.

Difficult discriminations evoke kappa bursts. Line A in Fig. 3, part 1, is the canthal electroencephalogram of a subject responding to the Time discrimination record of the Seashore Measures of Musical Talent. The subject, who is required to tell whether the second of two tones is longer or shorter than the first, pressed the signal key (recorded on line B) twice if the second tone was longer and once if it was shorter. Fifty rather difficult discriminations are presented on the record. Line C is the 8- to 12-cycle accumulation. The short straight lines marked by T indicate the interval between the start of the first tone and the end of the second tone. A burst of kappa is seen to be associated with each choice situation, especially the first. In Fig. 3, part 2, the subject was given a choice reaction test, in which he decided whether a sound was "long" or "short." The technique was first to use sounds that were obviously either long or short and then to reduce the time difference. The subject was instructed to respond by pressing a key to long sounds but not to short ones. The downward deflection on line A shows the duration of the stimulus;

A number of different controls have been employed. First, there was the possibility that kappa waves were due to periodic physiological changes. However, there was no relation to the breathing cycle or to unusual or forced breathing. Likewise, the bursts were independent of pulse rate. Eye movements and blinks are not correlated with the kappa bursts. Talking aloud or to oneself is not associated with the rhythm. Finally, merely hearing a stimulus or making the response of key-pressing did not produce kappa waves.

The voluntary control by the subject induced by verbal instructions has been found to be important in the production or nonproduction of kappa waves. For example, the accumulated record of one subject was above a constant base line 54% of the time while doing mental multiplication and only 17% while attempting to "keep his mind a blank." He was fixating in both cases. Corresponding percentages of another subject were 35% and 2%. Large differences were also found on the Time discrimination record of the Seashore measures. When the subject tried to make correct discriminations, a burst

of kappa waves above a constant base line occurred during 85% of the choices for one subject; when he merely pressed the key without trying to discriminate, only 17% of the paired tones resulted in this level of activity. Comparable figures for another subject were 36% and 16%.

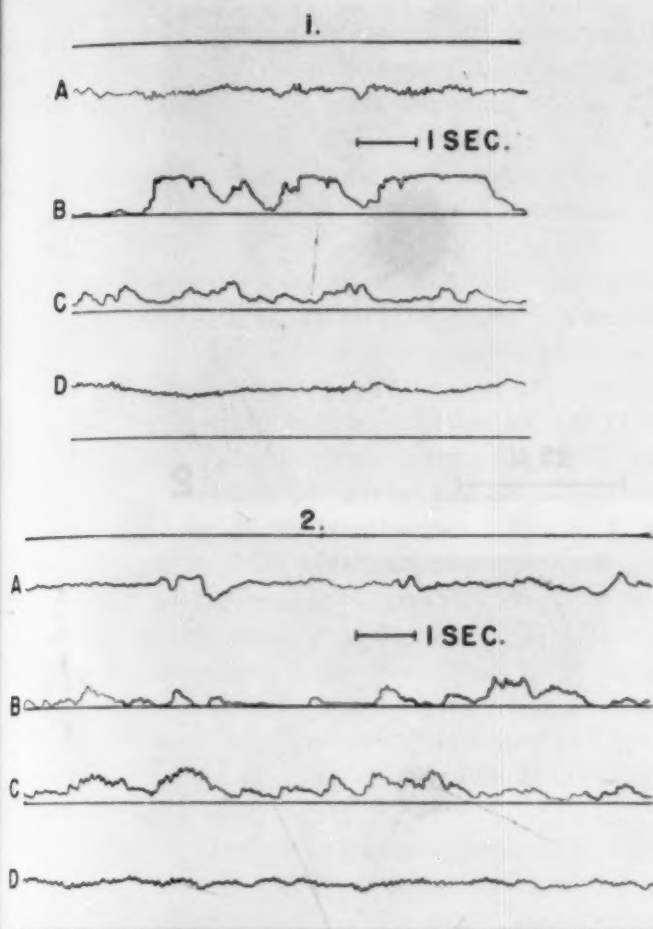


FIG. 4. Part 1, Simultaneous record of kappa and alpha waves during mental multiplication; Part 2, simultaneous record of kappa and alpha waves with "mind a blank."

Out of 31 subjects tested, 18 have shown a recognizable amount of 8- to 12-cycle/sec activity from the canthal placement. Attempts were made to record these waves on subjects not initially exhibiting them by using other electrode placements on the front part of the head. For the most part, these attempts were unsuccessful. Also, the difference in level due to the conditions previously described seems most clear cut for the subjects whose amplitude of kappa activity is highest. Further investigation is required to determine whether kappa waves are actually absent in subjects showing little or no 8- to 12-cycle bursts from the canthal placement. The possibility of such artifacts as poor conduction through the skull and surrounding tissues must be taken into account.

It appears certain from the data available that kappa waves are not directly related to previously described bioelectrical phenomena. Of course, they closely resemble the alpha rhythm in frequency. The conditions for occurrence are, however, different—or perhaps opposite. Alpha waves generally increase in amplitude when the eyes are closed, but kappa waves show no

regular differences between conditions of eyes open and eyes closed. Mental arithmetic often inhibits alpha (4), whereas kappa waves appear frequently during mental addition or multiplication. Fig. 4, part 1, shows a section of record in which kappa (line A) and alpha (line D) were recorded simultaneously while the subject was doing mental multiplication (eyes fixated). Line B is the accumulation of kappa; line C shows the accumulation of alpha. It is evident that kappa bursts are frequent and are unrelated to alpha activity. Part 2 of Fig. 4 shows a comparable section of record when the subject's eyes are closed and he is trying to "keep his mind a blank." Here, alpha activity is high and kappa low.

The position of the electrodes suggests that the source of kappa bursts may be the temporal lobes of the brain.

The following summary statements may be made:

(1) An intermittent spindle-shaped electroencephalogram with a frequency of 8-12/sec and a maximum amplitude of 20-30 microvolts has been recorded from bipolar electrodes placed just back of the external canthi of the eyes.

(2) These bursts appear to be associated with the process of thinking (discrimination, choice reaction, mental arithmetic, problem solving, etc.).

(3) The bursts are unrelated to previously described alpha activity.

(4) Half of the subjects so far tested exhibit the phenomenon.

(5) It is suggested that the source of the new EEG may be the temporal lobes of the brain.

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3. KENNEDY, J. L., and TRAVIS, R. C. *Science*, 1948, **108**, 183.
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Autoradiographs of C^{14} Incorporated in Individual Blood Cells¹

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Since Altman, *et al.* (2) demonstrated that the alpha-carbon atom of glycine labeled with C^{14} is incorporated into the heme and globin moieties of hemoglobin, it was believed that the incorporated C^{14} in an individual blood cell could be demonstrated by an autoradiograph. To this end a male rat weighing 120 gm was given a

¹This paper is based on work performed under contract with the U. S. Atomic Energy Commission at the University of Rochester Atomic Energy Project, Rochester, New York.

total of 3 μc of glycine containing C^{14} in the alpha-carbon atom.² The specific activity of this glycine was 1.83 $\mu\text{c}/\text{mg}$. The glycine was administered by means of three intraperitoneal injections of 1 μc each, given at hourly intervals. Blood was taken from the tail veins 25 hrs after the first injection, diluted with serum made

concentrated focally about certain individual cells to form autoradiographs. Other cells, such as the erythrocytes in this particular field, produced no autoradiographs. In order to make the autoradiographs prominent at this magnification ($\times 440$), the NTB plate from which this photomicrograph was made was developed for a longer

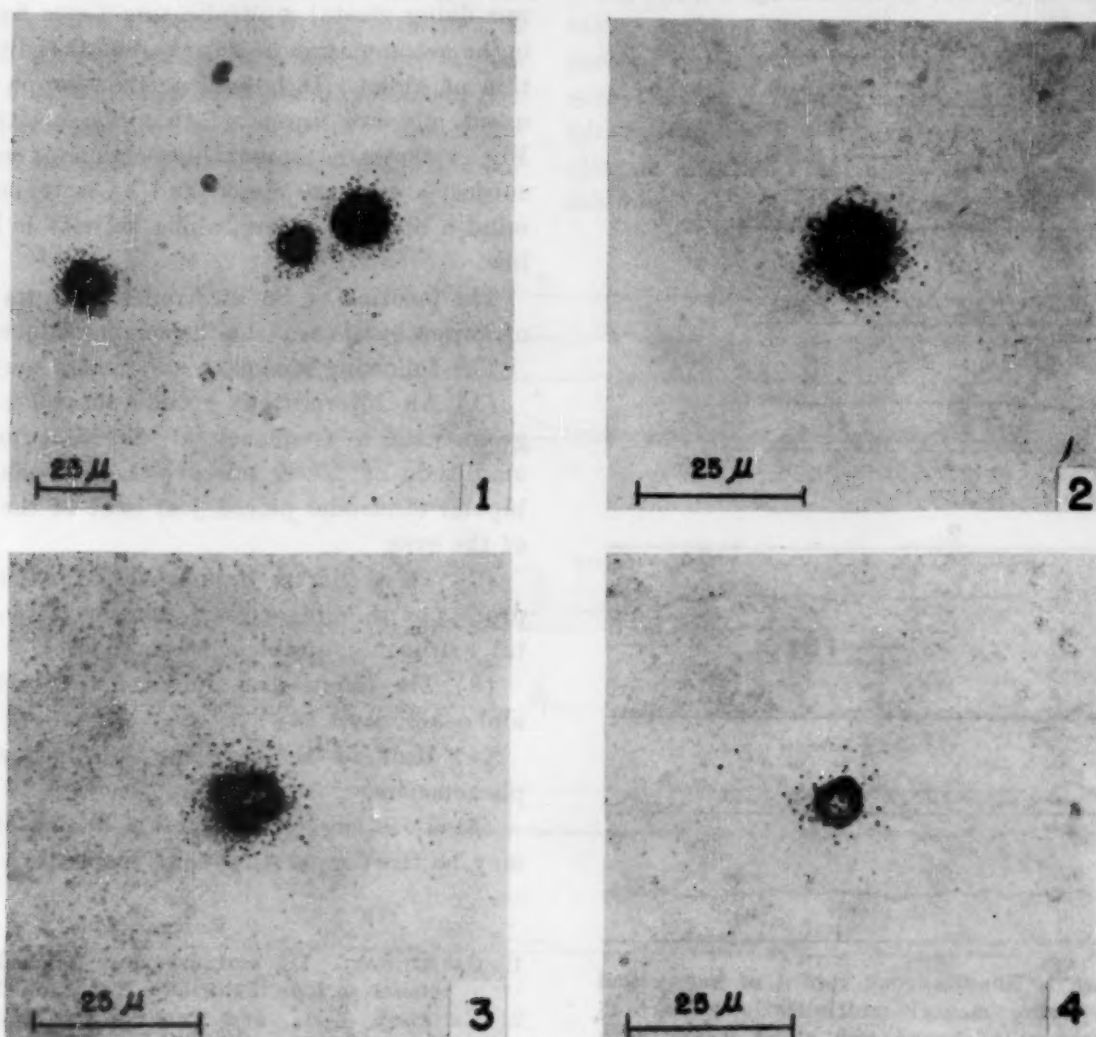


FIG. 1. Autoradiographs of C^{14} incorporated in individual blood cells: (1) Field of test blood smear illustrating nonuniform distribution of silver grains and concentration of grains around certain cells ($\times 440$). Cells without autoradiographs are erythrocytes. The exposed test plate from which this photomicrograph was made was soaked in water for 5 min and developed in a dilute solution of D-19 at 20°C for 25 min ($\text{D-19}:\text{H}_2\text{O}=1:3$). (2) Lymphocyte ($\times 950$). (3) Polymorphonuclear leucocyte ($\times 950$). (4) Erythrocyte ($\times 950$).

The exposed test plate from which photomicrographs 2, 3, and 4 were made was developed for 2 min in D-19 at 20°C .

from dog blood, and smeared directly on an Eastman NTB emulsion. The smears were dried in air and fixed in methyl alcohol. After an exposure period of 67 days the emulsion plates were developed in Kodak D-19 and cleared, and the cells stained with Wright's stain. The blood smears were made sparsely cellular to insure clear-cut, well-defined autographs and minimal cell clumping.

In order to prove that the autographs are not the result of chemical fogging, similar smears of blood from a control rat were exposed under identical conditions. Details of the technique for preparing blood smears on a photographic emulsion will be described later (4).

The accompanying photomicrographs (Fig. 1) show autoradiographs resulting from beta emissions from C^{14} incorporated into blood cells. In Fig. 1, 1, it can be seen that the silver grains are nonuniformly distributed, being

² This sample of glycine was kindly supplied by B. M. Tolbert, of the University of California.

time in D-19 than that used for photomicrographs 2, 3, and 4. This procedure enhanced the visibility of the beta radiation effects, but obscured cellular detail. Silver grains between the autoradiographs on the test plates, and in all regions of the control plates, are relatively very small in number per unit area and randomly distributed, as is extraneous background fog.

The identifiable cells on the test plates include lymphocytes, polymorphonuclear leucocytes, and erythrocytes. Although this technique is not at present completely quantitative, it is apparent that the percentage of cells of each type associated with definite autoradiographs declines in the order: lymphocytes, polymorphonuclear leucocytes, erythrocytes. One possible explanation for this phenomenon lies in the difference in the rate of formation among the three types of cell under consideration. Although the exact life spans of circulating rat blood cells are not known, it is agreed that the erythrocyte has a

much longer life span than the leucocytes, and it is probable that the polymorphonuclear leucocyte has a slightly longer life span than the lymphocyte. It is to be expected, therefore, that the percentage of new cells of each type in the circulating blood of a normal rat at a given time would decrease in the order mentioned above.

Thus, most of the lymphocytes are associated with autoradiographs. The polymorphonuclear leucocytes are associated in several cases with autoradiographs, despite the fact that these are the least numerous of the three cell types in the rat blood. The erythrocytes rarely produced an autoradiograph under our experimental conditions, despite their relatively large numbers in the circulating blood.

The grain concentration, i.e. number of silver grains per unit area, in the autoradiographs, which is a measure of the relative amounts of C^{14} incorporated in the cells, varies in each cell category. There are cells of each type which reveal no C^{14} incorporation detectable by this technique. Of those which yield autoradiographs, however, the concentration of silver grains is generally greatest in the case of the lymphocytes. Fig. 1, 2, represents approximately the average grain concentration in autoradiographs associated with lymphocytes. The maximum grain concentration in autoradiographs associated with polymorphonuclear leucocytes (Fig. 1, 3) is less than that found with most lymphocytes. The maximum grain concentration associated with erythrocytes (Fig. 1, 4) is less than that of most of the definite autoradiographs given by leucocytes.

The concentration of silver grains appears to be higher in the case of those cells containing relatively larger amounts of nuclear material. It seems reasonable to assume that the cells which show the presence of C^{14} have incorporated the labeled materials in their proteins. Since, according to Abrams, *et al.* (1), glycine is a specific precursor for purines of the nucleic acids of yeast, much of the C^{14} activity may reside in the purine moiety of the nucleoproteins. Inasmuch as the concentration of nucleoproteins is the highest in lymphocytes, this offers a possible explanation for the variation in grain concentration among the three cell types.

It is probable that glycine is incorporated into the hemoglobin of the red cell in the bone marrow and not in the circulating blood. This contention is supported by *in vitro* studies of London, *et al.* (5), which showed that the synthesis of heme from glycine does not occur to a detectable extent in normal human peripheral blood incubated with glycine labeled with N^{15} , and by the finding that rabbit bone marrow homogenates incorporate appreciable amounts of C^{14} -labeled alpha-carbon of glycine in hemin within 3 hrs of incubation (3). The present experiment strongly suggests, therefore, that the red blood cells associated with autoradiographs are cells which were recently formed and introduced into the circulating blood within the 25-hr period of the experiment.

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Histological Localization of Newly-formed Desoxyribonucleic Acid¹

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The histological localization of newly-formed desoxyribonucleic acid was attempted by the use of the "radioactive autograph" technique in the tissues of animals treated with large amounts of radiophosphorus.

Female rats weighing from 50 to 70 gm were given a single subcutaneous injection of about 1 mc of P^{32} in a solution of H_3PO_4 containing 25 μ g of phosphorus. The animals were sacrificed 2 or 24 hrs later. The tissues were fixed in neutral formalin, dehydrated in dioxane, embedded in paraffin, sectioned, and mounted on glass slides in the routine manner. After deparaffination the slides were treated for 1 hr at 40° C with a 0.05% solution of ribonuclease in citrate-phosphate buffer at pH 7, control slides being similarly taken through a buffer solution without ribonuclease. Half the slides were stained with hematoxylin-eosin, the others being left unstained. The slides were then coated with photographic emulsion according to the "coated autograph" method (1, 3).

Most of the phosphorus compounds originally contained in the tissue sections were extracted during the preparation of the autographs. Thus, phospholipids were removed when the tissues were passed through several baths of dioxane and the slides through xylol and alcohol. Similarly, water-soluble phosphates, such as phosphate ions, hexose-phosphates, creatine-phosphate, were eliminated during either fixation, staining, or ribonuclease-buffer treatment. It was shown on control slides stained with pyronine that ribonuclease removed the cytoplasmic basophilia from pancreas and liver; therefore, ribonucleic acid was assumed to have been more or less completely extracted. It was concluded that desoxyribonucleic acid was the only phosphorus compound remaining in the sections in significant amounts. Autographs of such sections should reveal the localization of the desoxyribonucleic acid formed since the time of injection of P^{32} .

The newly-formed desoxyribonucleic acid was found to be abundant in lymphatic tissue. Thus, the reaction was pronounced in the cortex of the thymus (Fig. 1) and moderate in other lymphatic organs. The myelogenous tissue of the bone marrow and that normally found in

¹ This work was supported by a grant from the National Cancer Institute of Canada. We wish to acknowledge helpful suggestions from J. H. Quastel and O. F. Denstedt, of this University.

the spleen and some lymph nodes of 50- to 70-gm rats reacted intensely.

A strong reaction was present in the ovary, where it was limited to the granulosa of some follicles (Fig. 2). The lack of reaction in other follicles (Fig. 2) may be due to their incipient atresia; or possibly such follicles may have reached full maturity.

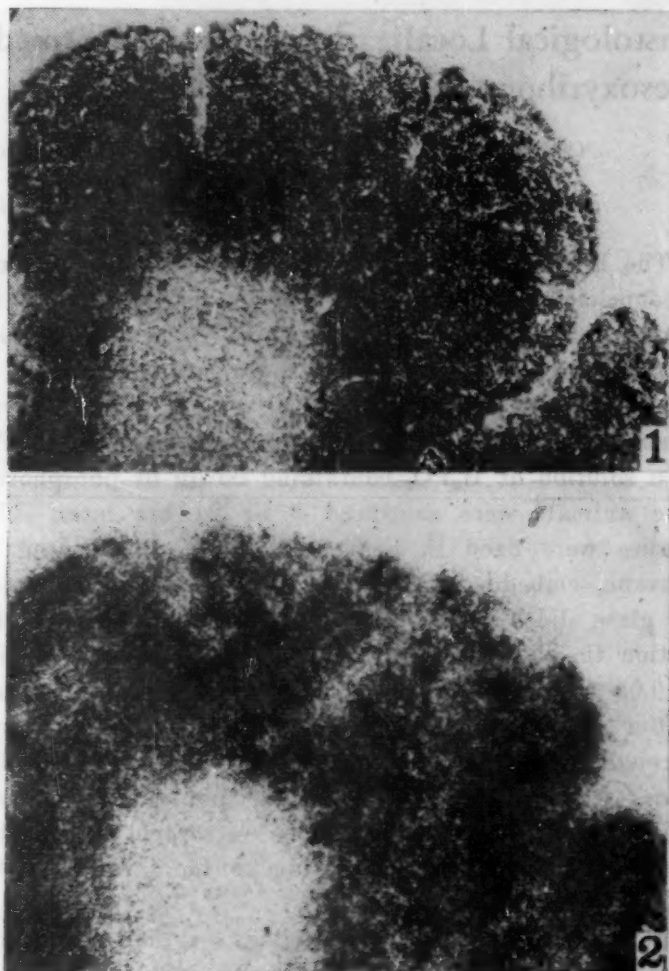


FIG. 1. (1) Thymic lobule of a rat sacrificed 24 hrs after P^{32} injection. A short exposure resulted in a slight autographic reaction which is hidden by the hematoxylin-eosin stain. Compare with (2), which is the same thymic lobule showing one of the following serial sections as an unstained autograph. The exposure was longer than in (1). The black reaction due to newly-formed desoxyribonucleic acid is intense in the cortex only. ($\times 80$.)

More or less intense reactions were present in many epithelial linings (intestine, stomach, esophagus, etc.). In contrast, most parenchymatous organs (pancreas, thyroid, etc.) and connective tissues showed no newly-formed desoxyribonucleic acid.

It should be emphasized that throughout the body the intensity of the reactions was roughly parallel to the mitotic counts, a fact which substantiates the theory (2) that phosphate ions enter the desoxyribonucleic molecule only at the time of mitosis.

Striking reactions were observed in the gastrointestinal tract. As early as 2 hrs after administration of P^{32} a definite reaction was noted in the crypts of Lieberkühn [Fig. 3 (5)], where mitoses are quite numerous. Twenty-four hours after injection an autographic reaction was found overlying the nuclei of the epithelial cells in the

lower part of the villi [Fig. 3 (6)]. Apparently the radioactive phosphorus had been incorporated into the desoxyribonucleic acid synthesized by the dividing nuclei in the crypts; and the young nuclei, loaded with radioactive desoxyribonucleic acid, had ascended the sides of the villi. This observation confirmed a fact previously foreseen on theoretical grounds (4), that the cells of the epithelium covering the villi originate in the crypts.

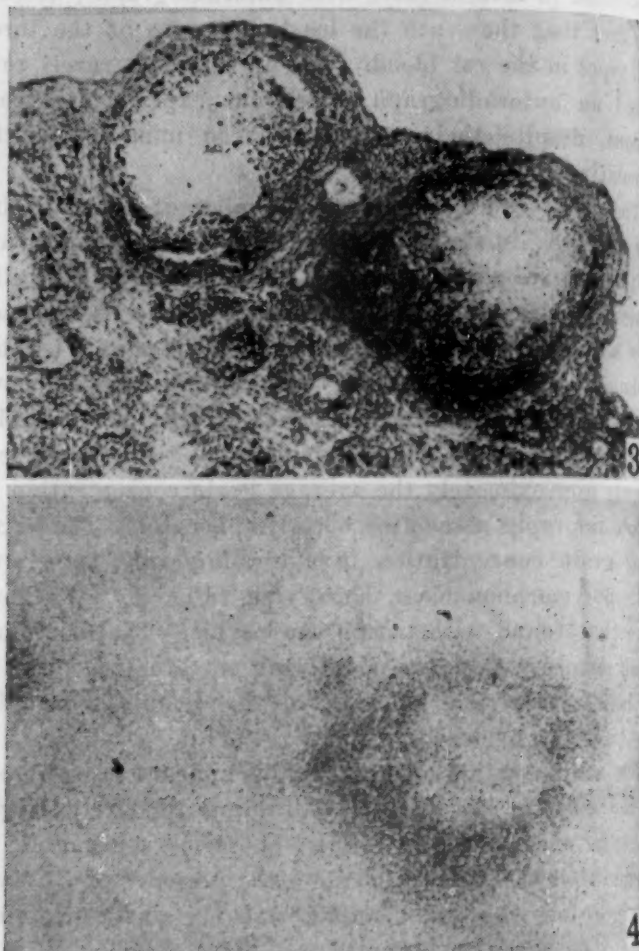


FIG. 2. (3) Ovary of a rat sacrificed 24 hrs after P^{32} injection. A short exposure resulted in a slight autographic reaction which is partly hidden by the hematoxylin-eosin stain. Compare with (4), the same region of the ovary, showing one of the following serial sections as an unstained autograph. The exposure was longer than in (3). The contrast between the right-hand side, reactive follicle and the left-hand side, nonreactive follicle is apparent. ($\times 80$.)

In both the fundic and pyloric regions of the stomach a slight but definite reaction was noted at the bottom of the gastric pits. Mitoses were found in this region, presumably insuring a constant renewal of the epithelium covering the gastric mucosa.

Slight reactions were also noted in liver, kidney, and muscle, where practically no cell division occurs. There is a possibility that these reactions were not due to desoxyribonucleic acid but to traces of unextracted ribonucleic acid or other phosphorus compounds rendered insoluble by fixation. For example, adenosine triphosphate might be retained in tissue sections as adenosine diphosphate.

Finally, an attempt was made to deduce the localization of newly-formed ribonucleic acid by comparison of the ribonuclease treated with untreated autographs. Newly-

formed ribonucleic acid was thus found in liver, kidney, adrenal cortex, and many epithelia. Large amounts were present in tissues where the neoformation of desoxyribonucleic acid occurred, especially in the crypts of the intestine. In contrast, several organs known to be fairly rich in ribonucleic acid, such as pancreas, salivary glands, and thyroid, did not show a significant amount of newly-formed ribonucleic acid.

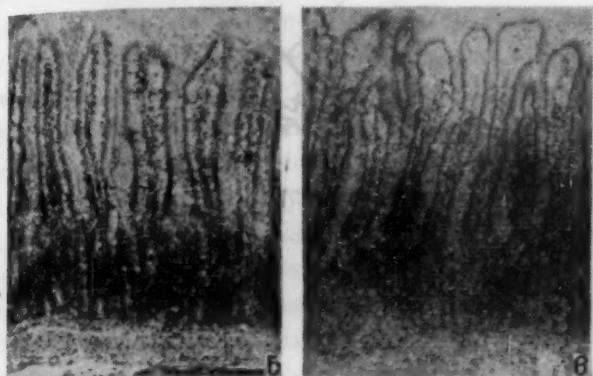


FIG. 3. (5) Duodenum of a rat sacrificed 2 hrs after P^{32} injection. The autographic reaction is located over the cells of the crypts of Lieberkühn, as indicated by the arrow. (6) Duodenum of a rat sacrificed 24 hrs after P^{32} injection. An intense autographic reaction is located over the nuclei in the cells of the villi epithelium; the upper limit of the reaction is indicated by the arrow. A less intense reaction is present in the crypts. ($\times 50$.)

Conclusion. Radiophosphorus entering into desoxyribonucleic acid at the time of mitosis may be localized by the "coated autograph" method in tissue sections treated with ribonuclease. The newly-formed desoxyribonucleic acid thus detected is found in the tissues where cell divisions are numerous, e.g. lymphatic and myelogenous tissues, ovarian follicles, intestinal epithelium, etc.

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Protoanemonin as a Mitotic Inhibitor¹

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Experiments are in progress in this laboratory to determine the effect on root tip mitosis of several drugs and other chemicals. Protoanemonin, $\text{CH:CH}\cdot\text{CO}\cdot\text{O}\cdot\text{C:CH}_2$, has been found to exert striking effects not only on the nuclei of the meristematic cells but also on the mitochondria and on the structure of the cytoplasm. It has previously been found to be effective as an antibacterial agent (2).

Seedlings of *Zea Mays* were grown in beakers lined with moistened filter paper, according to the method of Albaum (3), until the roots had reached a length of about 1 cm, and were then transferred to similar beakers in which the filter paper liner was moistened with a solution of protoanemonin. Roots were treated in this way with various concentrations of the drug (10^{-3} M to 10^{-5} M) for various lengths of time (2 hrs to 24 hrs) and then fixed in each of three fixatives: Navashin's for nuclear details, a modified form of Erliki's (5) for mitochondria, and a mixture of chromic sulfate, formaldehyde, and copper hydroxide (4) for cytoplasmic structure. The root tips were dehydrated by the ethyl-normal butyl alcohol schedule, imbedded in paraffin, sectioned at 8 μ , and stained in iron alum-hematoxylin.

The most striking effect of protoanemonin is the disappearance of mitochondria. The Erliki fixation shows them well in untreated root tips, but not in root tips treated for 24 hrs at 10^{-5} M or higher concentrations or for 2 hrs or longer at 10^{-3} M. Cytoplasmic structure is badly disrupted by treatment at the stronger concentrations and for longer periods, as shown by the chromic sulfate-formaldehyde fixation. In the untreated meristem the image after this fixation is that of an even-textured cytoplasm interrupted by many small, sharply outlined vacuoles. After the longer and stronger treatments the cytoplasm is reduced to irregular strands and darkly staining granules. After shorter treatments and at lower concentrations the only effect is some coalescence of the vacuoles.

The nuclear effect of protoanemonin is strikingly different from that of colchicine. Treatment with the latter drug leads to an abnormally high frequency of metaphases. Treatment with protoanemonin at 2.15×10^{-4} M or higher concentrations for 24 hrs or at 10^{-3} M for 4 hrs or longer reduces the frequency of recognizable mitotic stages to a statistically significant degree. After the longer and stronger treatments, all the nuclei of the root tip are in a condition which resembles interphase or prophase. A small proportion of the nuclei superficially resemble late prophase.

In these nuclei the chromosomes are abnormally contracted, as are colchicine-treated chromosomes, but there is no evidence of chromatid separation or of polyploidy, which are characteristic of colchicine. It appears that protoanemonin exerts its inhibiting effect on mitosis at a different stage in the mitotic cycle than does colchicine. A more detailed report of these results will be published elsewhere (1).

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Evidence for the Existence of a Low-Mass Mesotron¹

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The photograph in Fig. 1 shows what may be interpreted as an elastic collision between a particle of mass about 10 times that of an electron and an electron in the gas of a cloud chamber. An explanatory diagram is given in Fig. 2. The photograph was taken at an altitude of 8,850m with a random expansion of a cylindrical cloud chamber 87 cm in diameter and 15 cm deep filled with approximately 1 atm of argon and saturated with ethyl-alcohol vapor. No magnetic field was present.

From the range of the electron, which stops in the gas, its velocity immediately after the impact is found to have been about $\frac{1}{2}$ of the velocity of light, and comparison of the ionization along the two tracks near the junction shows the heavier particle to have had about the same velocity. A nonrelativistic treatment will therefore give a reasonable first approximation for the masses involved in the collision. Since the energy transferred to the electron is about 75,000 eV while the binding energy of even the K-shell electrons of argon, the heaviest atom in the chamber gas, is only 3,200 eV,



FIG. 1

the collision may be considered to be elastic and the laws of conservation of momentum and energy applied.

The following relation results:

$$\frac{M}{m} = \frac{\sin(2\theta + \phi)}{\sin \phi},$$

where M is the mass of the heavy particle, m is the mass of the electron, and θ and ϕ are the angles indicated in Fig. 2.

¹This work was supported in part by the Office of Naval Research and the Atomic Energy Commission.

To measure these angles, which are considerably smaller than the projected angles in the two stereoscopic views in Fig. 1, the two negatives were reprojected through the original camera arrangement upon a screen. The screen was then tilted until the two images coincided, and the true angles in space were measured. When so projected, the right and left images of both tracks coin-

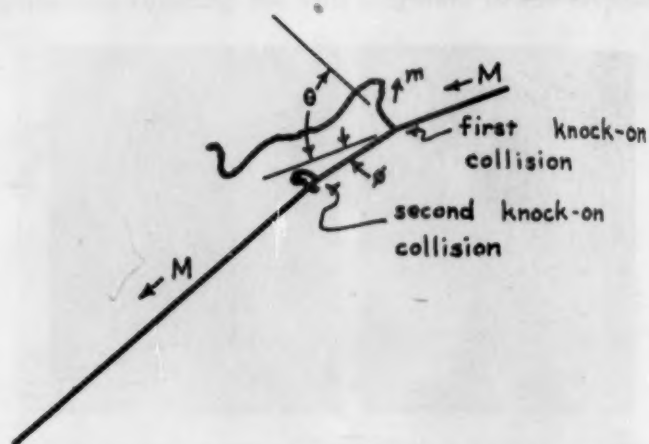


FIG. 2

cided near the junction, indicating that the collision was approximately coplanar.

The values of $\theta = 39^\circ$ and $\phi = 5.0^\circ$, when substituted in the equation above, give a mass ratio of 11.4 for the two particles involved in the collision.



0 1 Scale: 1 cm

Although the value of θ may be considered to be doubtful because of the possibility of a single large-angle scattering of the electron immediately after it was accelerated by the knock-on collision, the maximum value of M/m that can be obtained for any value of θ is $\csc \phi$, which is 11.5 for the value of ϕ given above. This maximum is relativistically correct for the rest mass ratio.

The lower limit for the mass ratio is still uncertain if the value of θ is considered doubtful. However, the possibility that the track could have been produced by

an electron can be ruled out on the basis of the ionization and degree of multiple scattering of the track. The ionization of the two tracks is roughly equal at the junction point and several times the minimum value for a singly-charged particle. Thus, the tracks indicate about the same velocity for the two particles but show a markedly smaller scattering for the deflected particle, indicating a heavier mass.

Another possible interpretation is that the track was caused by a mesotron or proton that was scattered by a nuclear collision very close to the point where the knock-on collision occurred. The probability of this explanation is reduced considerably by the occurrence along the same track of a second knock-on electron of shorter range with a correspondingly smaller deflection of the heavy particle. Since the value of θ for this second collision is close to 90° , in which range the mass ratio varies rapidly with θ , the uncertainty in the exact direction of the knock-on electron caused by its large scattering makes it impossible to calculate a significant mass ratio. The value of $\csc \phi$ for this collision, however, sets an upper limit of 30 for the mass ratio.

Measurement of Radiocarbon as CO_2 in Geiger-Müller Counters¹

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The gas counting of radioactive carbon dioxide has been studied as a quantitative procedure in the range 2–12 cm Hg pressure. The results presented below demonstrate that this highly efficient counting method may be carried out with routinely available equipment furnishing up to 2,000 or 2,500 v.

Miller and Brown (1, 2) have recently reported a satisfactory counting technique at CO_2 pressures from 10 to 50 cm Hg admixed with 2 cm pressure of CS_2 vapor. They report threshold voltages over the range 1,800–4,500 v, depending on counter diameter and CO_2 pressure. This counting gas mixture was used in the experiments reported here. Using a 4-mil tungsten anode, 15.5-mm I.D. Geiger-Müller counter tube and a CS_2 partial pressure of approximately 2 cm, threshold voltages ranged from 1,450 to 2,200 v for the 2–12 cm pressure range. The measured activity was found to be directly proportional to the partial pressure of the radioactive gas sample admitted to the tube. This indicates that the counting efficiency of the tube for beta particles emitted by carbon 14 is very close to 100% in the effective volume over this pressure range.

¹The research described in this paper was aided in part by a grant to Queens College by Research Corporation. The author acknowledges his obligation to E. Kuchinskas, who assisted in the counting measurements, and to L. Marinelli and H. Beyer, of the Sloan-Kettering Institute, for their advice and cooperation.

Pure CO_2 was prepared by heating sodium bicarbonate (E. and A. Tested Purity Reagent) at 350° . Water vapor was condensed in a dry-ice trap. Radioactive CO_2 was prepared by addition of perchloric acid to barium carbonate containing carbon 14. Mallinckrodt carbon disulfide (analytical reagent; boiling range, 46° – 47°) was used without further purification.

A scaling circuit and 2,500-v stabilized voltage supply was used with a modified Neher-Harper quenching tube and cathode follower. The latter unit contained two 6AG5 tubes, a 5.6-megohm grid resistor, and a variable cathode resistor usually set to 7,000 ohms. The Geiger-Müller tubes were glass envelopes containing as cathode chemically deposited silver covered with colloidal graphite (1, 2). Tungsten wire (4 mil) anodes were used.

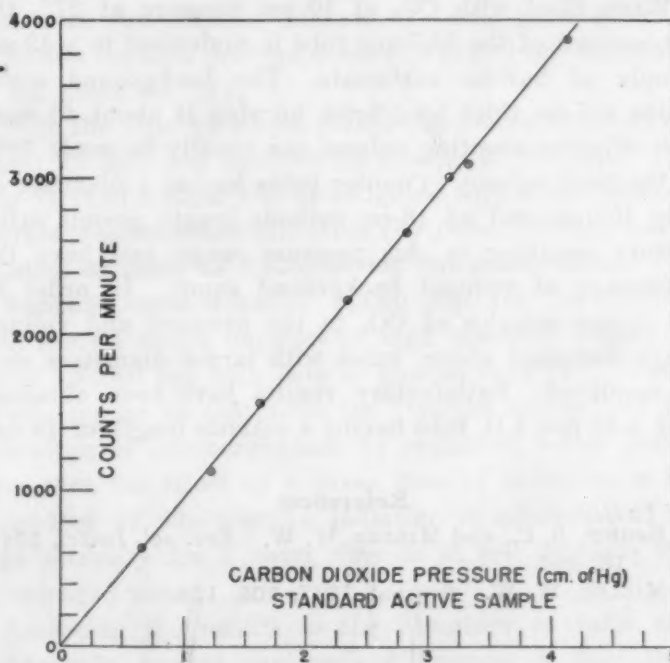


FIG. 1

A "cold finger" attached to the lower portion of the counter tube permitted quantitative condensation of CO_2 and CS_2 at liquid nitrogen temperatures. CO_2 pressures were measured with less than 0.3% error using a constant-volume mercury manometer and "cold finger" having a combined volume of about 18 ml. The resolving time was measured using two external radium sources and was found to be 4.1×10^{-5} min. Corrections using this resolving time were applied to the data.

In Fig. 1 the corrected counts per minute are plotted as a function of the partial pressure of a reference radioactive CO_2 sample using a counter tube having a 15.5-mm I.D. and 15-cm length of cathode surface. The pressures correspond to a temperature of 27.0° . The partial pressure of carbon disulfide in these fillings was 1.85 cm Hg (equivalent to one "doser" volume of vapor in the filling line when the liquid is maintained at 0.0°). In the case of the point closest to the origin, inactive CO_2 was added until the total pressure of CO_2 was 5.8 cm. The average deviation of the experimental points from the straight line drawn in Fig. 1 is 1.1%. The range of CO_2 pressures plotted extends to 4 cm Hg. Further measurements made after adding inactive CO_2 up to pressures of about 10 cm Hg checked the line

drawn in the figure within 1-2%. Several measurements were made in which the CS_2 pressures were 0.9 and 3.5 cm. These results were in agreement with the line drawn in Fig. 1 within 1-2%.

The threshold voltage for partial pressures of 1.0 and 1.85 cm Hg, respectively, of CO_2 and CS_2 is about 1,400 v. An average increase in threshold voltage of about 80 v/cm increase in CO_2 pressure was observed. The following conclusions concerning plateau lengths are based on about 20 fillings over the range 1-7 cm CO_2 pressure: Below 2 cm the plateau length is less than 100 v; over the range 2-3 cm it increases from about 100 to 200 v; and above 3 cm it is usually greater than 200 v. The plateau slope is, on the average, less than 2%/100-v interval and is frequently observed to be less than 1%.

When filled with CO_2 at 10 cm pressure at 27°, the CO_2 content of the 15.5-mm tube is equivalent to a 43-mg sample of barium carbonate. The background count inside a 5-cm thick lead brick housing is about 40 cpm. The effective counting volume can readily be made 70% of the total volume. Counter tubes having a diameter of only 10 mm and an 18-cm cathode length permit satisfactory counting in this pressure range and have the advantage of reduced background count. In order to use larger samples of CO_2 in the pressure and voltage range discussed above, tubes with larger diameters may be employed. Satisfactory results have been obtained with a 32-mm I.D. tube having a cathode length of 18 cm.

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Reduction of Undesirable By-Effects in Products Treated by Radiation

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In previous publications (1) we have discussed the sterilization and preservation of food in the raw state by use of ultrashort application periods of penetrating electrons as obtained from the Capacitron. In this connection we have already emphasized the importance of having optimum outside conditions during irradiation of various foodstuffs and therapeutics in order to avoid unspecific side reactions.

While it is accepted generally that corpuscular radiations of all kinds, within their penetration range, are able to inactivate microorganisms and also, in many cases, stop or inhibit enzymatic action, little has been published about the suppression of changes in taste, odor, appearance, etc. of the products so treated.

The ideal would be, of course, to inactivate enzymes and microorganisms without influencing the products to

be preserved in any other way. Although this ideal cannot always be achieved, attempts must be made to come as near as possible to such a goal if a preservation and inactivation method by radiation is to be at all successful.

Sterilization and preservation at low temperatures is a problem of fundamental importance. Therefore, it is of great interest to determine if, in principle, undesirable side reactions are something which is inherent in biologically active rays or if these can be minimized with the aid of certain procedures. Many experiments performed by ourselves or other investigators gave foundation to the belief that many of the changes and reactions formerly attributed to the action of rays could be avoided if outside conditions were created which would sterilize in any desired state—raw, partly or fully cooked—with as little damage as possible. It should be kept in mind that the taste and odor changes occurring in food products are, in the last analysis, chemical changes. Such changes would also be harmful, for instance, in the preparation of vaccines by means of radiation. Therefore, vice versa, better antigenicity should be obtained by killing the microorganisms without any chemical changes at all.

In 1913 Duane and Scheuer (2) demonstrated that ice irradiated with radon at -183°C did not give rise to any hydrogen peroxide formation whatsoever. More recently Svedberg and Brohult (3) have shown that irradiation of hemoglobin and serum albumin with alpha rays at room temperature and at 0°C causes the formation of low molecular substances, as revealed in the ultracentrifuge by a very pronounced polydispersity of the proteins. When irradiated at the temperature of liquid air, hemoglobin showed no change whatever, even after exposure to 5 times the doses required to give a noticeable effect at room temperature. Serum albumin was only slightly affected.

We find that in the case of bovine plasma albumin 7,000,000 rep (3) in the form of high-speed electrons will produce profound changes in the liquid state, whereas irradiation with the same dosage at -50°C has little effect.² However, the lethal action of penetrating electrons is affected only to a minute extent whether microorganisms are treated at room temperatures or in the frozen or deep-frozen state. This fact contributes again to underlining the selective effects possible by employing penetrating radiation.

In the case of many foodstuffs, cooling has a distinctive effect on the exclusion of undesirable side reactions, particularly if this method is combined with a partial evacuation in order to remove as much air as possible during the process of irradiation. We mentioned in our first

¹The temperature effects caused by penetrating electrons in the absorber are negligible. A dose of 100,000 Roentgen Equivalent-Physical (rep) is equivalent to 8.5×10^6 ergs/cm² which corresponds to a temperature rise in water of 0.2°C . We find that 600,000 rep constitutes a 100% killing dose for bacteria and spores in foods. This would be equal to a temperature rise of 1.2°C .

²We are indebted to Kurt G. Stern, Polytechnic Institute of Brooklyn, for these results, obtained by electrophoresis and ultracentrifuge experiments.

port (1) that partial evacuation would be of advantage, but we were doubtful at that time that such a partial evacuation would be effective enough in view of the fact that in moisture-containing foodstuffs, for obvious reasons, it had to be limited in order to avoid too much dehydration.

Recent experiments have shown, however, that evacuation well within the reach of practical possibilities is very effective in avoiding taste and odor changes and that a great number of products can now be preserved in this manner without a trace of undesired side reactions. Powdered products such as soy flour, which formerly showed very objectionable off-taste and flavor, could be treated without noticeable changes in color, odor, or taste. As a rule, the changes are the smaller the more free air has been removed, but beneficial effects are marked only below a certain threshold of air pressure.

The evacuation procedure is relatively easy in the case of dry, finely divided products where good vacuum can be achieved readily, but it is slightly more difficult in liquids, especially in those of higher viscosity, and in compact solids. In liquids and in solids, occluded air can be removed more easily if elevated temperatures of the order of 35°-50° C can be applied without changing the appearance of the product. If the product is precooked, the extent of necessary evacuation is, of course, reduced considerably. Evacuation alone is satisfactory for the elimination of unwanted side effects in many products, whereas others—especially certain therapeutics, such as vaccines—must be evacuated first and later kept frozen to the required degree while being exposed to the action of electrons.

The irradiation was carried out in special glass containers or within an irradiation chamber which could be evacuated and which was fitted with an electron-permeable entrance device of about 5" in diameter.

The importance of the reduction of air pressure has long been recognized in normal canning processes. In canning, however, this method is used to avoid oxidation during subsequent shelf life of the product, whereas in preservation by means of irradiation, the emphasis must be placed on the moment of processing proper in order to diminish interaction between free air and the treated products. In the case of air removal one normally thinks of avoiding oxidation; yet it has to be kept in mind that side reactions also may be caused by interaction with highly reactive nitrogen oxides formed from air by the intense radiation.

It is obvious that air removal would, at the same time, so materially decrease this type of reaction. The addition of antioxidants will partly eliminate the need for air removal in all those cases where molecular oxygen acts as an essential component of a biocatalytic chain reaction.

While the exclusion of air should diminish to a great extent irradiation odor and flavor caused by any type of biologically active rays, it would be interesting to ascertain whether the combination of low air pressure and very short exposure time as it exists in the instance of the Capacitron plays an important part in the beneficial effects observed in our experiments.

We find, for instance, discrepancies in the inactivation doses³ of certain microorganisms such as bacterial spores, bacteriophages, and viruses.⁴ While we normally would be inclined to attribute such differences to errors in experimental technique, the fact remains that in the case of vegetative bacteria our observations are in conformity with the results in the literature (4). In the case of particles of small size, such as phages and viruses, and of organisms of higher radiation resistance, such as spores, we find, however, that the inactivation doses required with electron impulses of relatively very great individual intensity and extremely short duration differ from the published data by factors ranging from 5 to 80. Thus, in the case of *B. mesentericus* spores we can produce inactivation with 11,000 rep, whereas inactivation with conventional sources of beta, gamma, or X radiation requires average doses of 120,000 rep according to the literature (4).

With the virus of mouse encephalomyelitis S. K. strain (size: 10 mμ) the inactivation dose is 35,000 rep. The only virus of similar size investigated with other beta-ray sources is tobacco necrosis virus (4) (size: 16 mμ), which requires as much as 2,800,000 rep for inactivation.

Vaccinia virus requires 11,000 rep for inactivation with short electron impulses of high intensity instead of about 100,000 rep with beta or gamma rays (4). These effects appear to contradict the "target theory" of inactivation of microorganisms by radiation, which postulates that the effect of a given dose of radiation is independent of whether the radiation is administered at high intensity for a short time or at low intensity for a prolonged time.

Accepting the results in the literature as valid and comparable, one of the main differences is that they were obtained with rays produced at low or comparatively low intensities and applied during relatively extended exposure times. It seems possible that in the case of very high intensities of radiation, and particularly in the present case where such greatly concentrated intensities are released in ultrashort times, new effects may become apparent which would call for a modification of the "target theory."⁵

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³ Inactivation dose: the dose of radiation which reduces the amount of surviving organisms to a fraction $e^{-1} = 37\%$ of the initial amount.

⁴ The detailed results of this work, carried out in cooperation with U. Friedemann (Brooklyn Jewish Hospital), will be published shortly elsewhere.

⁵ A more detailed discussion concerning this phenomenon will be published elsewhere in the near future.

The Viability of Individuals Heterozygous for Recessive Lethals¹

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The significance of recessive lethals for the dynamics of populations is often considered solely in relation to their effect in homozygous or hemizygous state. The assumption is thus made that individuals heterozygous for these lethals are equivalent to homozygotes free from the lethal alleles. This assumption has been tested for 33 sex-linked lethals in *Drosophila melanogaster* and found to be incorrect for the majority of them.

TABLE 1

RESULTS OF TESTS FOR VIABILITY OF HETEROZYGOTES
FOR 33 SEX-LINKED LETHALS

No. and source of lethals	Females heterozygous for		
	lethal	normal	doubtful
26, from irradiated sperm ..	4,860	5,210	236
7, from control sperm	1,366	1,551	75

The sex-linked lethals tested consisted of 7 spontaneous lethals and 27 lethals discovered in low-dosage X-ray or gamma-ray irradiation experiments. A considerable number of these "experimental" lethals must be spontaneous ones which have arisen independently of the irradiation. All lethals occurred in an X-chromosome derived from the highly homogeneous Canton-S stock of *Drosophila*.

stitutions was present in any specific individual. For each lethal an average of 472 F₂ females were thus tested. Any test culture which yielded one or more wild type males was classified as signifying the maternal genotype Muller-5/+; and any test culture with no wild type males and at least 6 Muller-5 males was regarded as signifying the maternal genotype Muller-5/lethal. Those cultures which yielded no wild type males but less than 6 Muller-5 males were considered as doubtful and listed separately. Finally, a fourth category was constituted of females which gave no offspring due to death, often by accident or sterility of these females or their mates.

A summary of the data is presented in Table 1. If one excludes "doubtful" and sterile tests, one may calculate for each lethal a percentage of lethal-bearing among all adequately tested females. The amount of this percentage is, of course, subject to a statistical error. Taking the observed values without consideration of the individual errors, one would expect approximately equal numbers to fall above 50% and below 50%, provided the viability of the genotype heterozygous for any one lethal were like that of a lethal-free genotype. In addition, the spread of values above and below 50% should be identical within statistical limits.

Actually, a plot of the viability values for the 33 lethals shows a twofold asymmetry (Table 2). There were 5 lethals within the class 49.6-50.5. Above this class only 5 values occurred; below it, 23. The values above 50.5 ranged within 4 classes; those below extended over 8, the lowest value being as low as 42.1%. Even within equal range of 4 classes above and below the 49.6-50.5 class the inequality of numbers of lethals is striking, being 16 and 1, respectively. These facts indicate that most sex-linked lethals tested have a considerable effect in decreasing the viability of females heterozygous for them.

In reaching this conclusion it has been assumed that the often large numbers of sterile or "doubtful" females were a random sample of the tested populations. The

TABLE 2

DISTRIBUTION OF VIABILITY VALUES FOR HETEROZYGOTES OF 33 SEX-LINKED
LETHALS IN PER CENT OF FEMALES ADEQUATELY TESTED*

41.6	42.6	43.6	44.6	45.6	46.6	47.6	48.6	49.6	50.6	51.6	52.6	53.6
-42.5	-43.5	-44.5	-45.5	-46.5	-47.5	-48.5	-49.5	-50.5	-51.5	-52.5	-53.5	-54.5
1	..	2	4	2	5	6	3	5	3	1	..	1

* "Doubtful" cases were excluded.

The test for equivalence or lack of equivalence of flies heterozygous for a lethal with flies homozygous for the nonlethal allele was carried out as follows: Females carrying a so-called Muller-5 X-chromosome (sc⁸¹B In-S w^{sc}) and a lethal-carrying chromosome were mated to Canton-S males. The F₁ females heterozygous for the lethal were mated to Muller-5 males and individually placed in culture bottles. Theoretically, their female offspring (F₂) should consist equally of Muller-5/+ and Muller-5/lethal genotypes. Individual progeny tests of these F₂ females were performed in order to determine which of these two con-

assumption is probably close to truth, since much of the sterility or low fertility may have been due to accidental causes in handling the cultures. Possibly, some of the sterile or low-yielding cultures owe their characteristic to the heterozygous lethal genotype. If this were the case a partial explanation would be provided for the deviations of lethal-bearing heterozygotes from the theoretical value of 50%. These deviations would to some extent be due to a higher number of sterile females or of those with low fecundity among lethal heterozygotes than among females free from a lethal.

From the point of view of a population even a slight decrease in the viability of individuals heterozygous for a lethal would be of greater significance for its well-being.

¹ This paper is based on work performed for the U. S. Atomic Energy Commission at the Atomic Energy Project, University of Rochester.

than the loss of lethal homozygotes. In any given generation the frequency of homozygotes is defined by p^2 —the square of the frequency, p , of the gene in the population—whereas that of the heterozygous carriers is $2p(1-p)$. For a rare gene (p being small and $1-p$ close to 1) the number of carriers may become hundreds of times as large as that of the homozygotes, so that a decrease in vigor of the carriers by, for instance, 5% will have a far greater effect than the complete elimination of the much rarer homozygotes.

The data presented here are of a preliminary nature. Retests of lethals may result in some changes in the specific figures given but will hardly lead to fundamental alterations in the conclusion.

In Vivo Iodination of Tissue Protein Following Injection of Elemental Iodine¹

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The work of Dvoskin (2) indicated that subcutaneous injection of elemental iodine into rats resulted in the synthesis of thyroxin-like material. This conclusion was reached from a study of the effects of the injected iodine on the histological appearance of thyroids of thiouracil-treated animals as well as on the growth curves of thyroidectomized young rats. It seemed reasonable to expect that this treatment would result in the formation of protein-bound iodine (PI) very probably due to the direct iodination of protein, similar to the purely *in vitro* production of iodinated protein.

TABLE 1

EFFECT OF SUBCUTANEOUS INJECTION OF ELEMENTAL IODINE IN PROPYLENE GLYCOL SOLUTION ON PLASMA PROTEIN-BOUND IODINE OF RATS

Treatment	Plasma PI γ/100 cc
Operated + propylene glycol for 30 days	4.6
" + 4 mg of I ₂ /kg/day for 1 day	34.8
" + 4 mg of I ₂ /kg/day for 30 days	86.3
" + 16 mg of I ₂ /kg/day for 30 days	260.7
Thiouracil + propylene glycol for 30 days	1.3
" + 4 mg of I ₂ /kg/day for 30 days	60.0
" + 16 mg of I ₂ /kg/day for 30 days	338.0
Thyroidectomized + propylene glycol for 30 days	1.1
" + 16 mg of I ₂ /kg/day for 30 days	251.0

In order to test this hypothesis, albino rats of the Prague-Dawley strain were injected subcutaneously with either 4 or 16 mg of elemental iodine (I₂)/kg of body weight, dissolved in propylene glycol (PG); the solvent alone was injected into controls. The use of propylene glycol eliminated the complications arising from the NaI required to dissolve I₂ in water or alcohol. The pro-

This investigation was supported by a research grant from the Division of Research Grants and Fellowships, National Institutes of Health, U. S. Public Health Service.

cedure for determination of PI was that recently described from this laboratory (1), with the modification that 0.5 ml of 1.5% As₂O₃ solution in 1N NaOH is used in the trap of the iodine-distilling apparatus instead of the Na₂SO₃ originally described. This alteration eliminates the aeration step, since there is no SO₂ present. It should be unnecessary to emphasize that every precaution must be taken to avoid contamination of the PI fraction being studied with elemental or inorganic iodine.

Table 1 shows the considerable increase in plasma PI after several different periods of injection. Even a single injection at the 4-mg level produced a considerable elevation in plasma PI by 24 hrs, and the values reached remarkable heights when 16 mg/kg was injected each day for 30 days.

TABLE 2

TISSUE PROTEIN-BOUND IODINE IN RATS 24 HRS AFTER SINGLE INJECTION OF PROPYLENE GLYCOL OR ELEMENTAL IODINE IN PG

Tissue analyzed		Protein-bound iodine after	
		propylene glycol (PG)	16 mg of I ₂ /kg in PG
Plasma	(γ/100 cc)	2.75	96.0
Thyroid	(γ/gland)	8.2	8.3
Kidney	(γ/100 gm)	11.7	86.8
Liver	(γ/100 gm)	17.9	46.7
Heart	(γ/100 gm)	10.4	25.6
Skeletal muscle	(γ/100 gm)	8.9	19.8
Injection site	(γ/100 gm)	0.0	36,230

Parallel determinations of oxygen consumption were performed on the animals shown in Table 1. These results indicate that the thiouracil-treated and thyroidectomized groups given the 16-mg/kg/day dose were the only ones to show increased metabolic rates. This finding suggests that a large proportion of the iodine combined with the plasma proteins must have been in a form other than thyroxin.

The possible role of the various organs of the animal body in the elaboration of the PI was investigated by comparing the tissue PI levels for kidney, liver, muscle, heart, and thyroid with that found at the site of injection. As can be seen from the results of one such experiment (Table 2), there can be little doubt that iodination of the tissue protein occurred primarily directly where the I₂ injection was made, since this PI value was so extremely high. Indeed, it would seem quite unlikely that free elemental iodine could exist in sufficient quantities in the blood plasma or in the lymph to be carried as such to liver or kidney for synthesis purposes. It is apparent from the thyroid results that this gland is not a major factor in the formation, and probably not in the breakdown, of the PI. On the other hand, the elevated kidney PI most likely denotes some excretory or "detoxifying" function of this organ.

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Comments and Communications

What Is the Pollinating Agent for *Hevea brasiliensis*?

Despite the fact that breeding experiments with *Hevea brasiliensis* Mull. Arg. (H.B.K.) have been carried on over a considerable number of years, the natural pollinating agent or agents are still unknown.

The writer spent almost 5 years working on the Firestone Plantations in Liberia, West Africa, and during that period carried on a number of studies to determine whether the trees are wind- or insect-pollinated.

The arrangement of the inflorescence in *Hevea*, in which, although the female flowers hang below the male flowers, the blossom is inverted and the short stigma is shielded by the sepals, indicates that the flowers are not wind-pollinated. Vaseline slides placed to one side and below the inflorescences failed to collect any pollen. The sparse production of pollen is a factor mitigating against successful wind-pollination; compared to many Temperate Zone plants, e.g., apples, cherries, etc., *Hevea* produces pollen in almost infinitesimal quantities. Also, the pollen grains are too large and heavy to float easily in ordinary air currents. If young inflorescences are bagged before the flowers are open, no fruit is produced, even in clones which are not entirely self-sterile. This eliminates the possibility that self-fertilization or apogamy is involved.

On the other hand, during months spent in hand-pollinating rubber trees, practically no insects were ever seen. Since the odor of the flowers seems stronger at night, especially around 8:30 P.M., indicating a possible increased attraction to insects at such hours, the possibility that night-flying insects might do the pollinating was investigated. However, no insects were found, except a few lonely red ants, and these, although they could be found at all times of the day or night, carried no pollen.

The wide distribution of *Hevea brasiliensis* Mull. Arg. (H.B.K.) throughout tropical regions in Asia, Africa, South America, etc. indicates that the insect vector or vectors, if any, are probably different in each of these widely separated regions; yet, it is true that in none of these regions has any insect been shown to be the pollinating agent. It is a notable fact that certain *Hevea* clones, such as Tjirandji 1, always bear seeds profusely, regardless of the region in which they are planted, while other clones which are poor seed bearers seem always to be poor seed producers wherever they are grown.

In plantings grown from seed, some trees almost always bear fruit each year, while neighboring trees may be alternate bearers, occasional bearers, or completely barren. This is also true to a lesser degree of the clones of *Hevea*, some of which, such as Tjirandji 1, Tandjong Kemala 12, etc., bear fruit very freely as a rule, whereas others, such as Bodjong Datar 5, Bodjong Datar 10, etc., are very poor seed producers and seem to

be almost completely self-sterile. Even within a clone there is considerable variation in bearing. Full sunlight, good drainage, and a dry period during flowering stimulate late seed bearing. Unhealthy or injured trees produce seed more heavily than healthy trees. The presence of a seedling tree in the midst of a clonal planting will cause the neighboring clonal trees to bear fruit in direct ratio to the distance from the seedling tree. Seed bearing along the boundary line between two clones is more prolific than within the clone.

The difficulties in pollinating *Hevea* by hand are, of course, well known. A final success of 5% is usually considered a satisfactory result, even though early fruit set may be as high as 90%. The loss of fruit occurs entirely during the first 6 weeks after pollination. For the next 8 weeks no loss normally occurs, except in cases of wind damage, etc. Girdling the fruiting branches or dipping a tongue of bark in hormone solution seems to be of no avail. However, spraying the young fruits with hormone solution has given promising results, in so far as retention of the fruits is concerned. Spraying inflorescences did not increase fruit set.

The present status of the problem would seem, from the foregoing experiments and observations, to be somewhat unsettled. We are inclined to assume that either wind or insects are concerned in the pollination of most tree flowers, and it is difficult to conceive of any other agencies being effective. The structure and arrangement of the inflorescence indicate strongly that wind is not the agent; yet, if an insect does the pollinating, why has it never been identified?

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Plasma Reduction of Methylene Blue

Stadie, in a report of a study of the reducing power of serum from subjects with malignant disease (*Science*, August 27, p. 211), indicated that the reduction of methylene blue by serum was due solely to the presence of newly formed S^{2-} . His measurements of such S^{2-} ion concentrations by means of methylene blue reducing time and iodometric titration failed to reveal any significant difference between serum samples from individuals with or without malignant disease. He indicated that these data lead to conclusions contrary to the independent reports of Savignac and myself (Savignac, et al. In *AAAS Research Conference on Cancer*. Washington, D.C.: AAAS, 1945. Pp. 241-252; Black. *Cancer Research*, 1947, 7, 321-325).

I should like to call attention to several features of this apparent discrepancy:

(1) I am in agreement with Stadie, and I believe Savignac is also, in regard to the importance of S^{2-} ions in the reduction of methylene blue in the technique employed. Experimental data on the sulfhydryl reduction of methylene blue with reference to alterations in malignant neoplastic disease were reported by me in *Cancer Research*, 1947, 7, 592. In this study I indicated that the increased reducing time observed by my technique

The Varieties, Quantities, and Purities of Stable Isotopes Which Have Been Concentrated Electromagnetically¹

The electromagnetic process for the separation of isotopes at Oak Ridge has been successfully applied to concentrating stable isotopes of the following elements:

Lithium	Copper	Indium
Magnesium	Zinc	Tin
Silicon	Germanium	Antimony
Chlorine	Selenium	Tellurium
Potassium	Bromine	Cerium
Calcium	Strontium	Tungsten
Titanium	Zirconium	Rhenium
Chromium	Molybdenum	Mercury
Iron	Silver	Thallium
Nickel	Cadmium	Lead

Additional elements are being added to this list from time to time.

From several hundred isotope collections approximations can be made as to the expected enriched concentration of an isotope, based on its natural abundance and the probable amount of an isotope which will be available. These expected concentrations and amounts are approximate because the natural abundance of an isotope is not the only factor which influences its enriched concentration after it has been processed in the mass spectrograph (calutron), and because the amount available for shipment will, of course, depend on the time given to collecting the particular isotope.

The following table summarizes the likely amounts of stable isotopes of the above elements available, together with their probable range of enriched concentrations:

If the natural abundance is :	The probable amount available for shipment is :	The expected enriched concentration is in the range :
(%)	(mg)	(%)
0.01 - 0.1	1	0.1 - 1
0.1 - 2	10	0.5 - 60
2 - 5	50	25 - 70
5 - 10	100	45 - 85
10 - 25	250	70 - 90
25 - 90	500	85 - 99
90 - 100	1,000	95 - 100

More specific information can be obtained from the Catalog of Stable Isotopes which is available from the Isotopes Division, Atomic Energy Commission, Oak Ridge, Tennessee.

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¹This document is based on work performed under Contract W-7405-Eng-26 for the Atomic Energy Commission by Carbide and Carbon Chemicals Corporation at Oak Ridge, Tennessee.

was not indicative of a change in the total protein or G ratio or the total -SH bonds potentially present. The technique employed appeared to measure the reactivity or the rate of appearance of such groups wherein a decided difference was found in plasma from patients with and without malignancies.

(2) The use of the technique which I have described previously has now been applied to almost 2,000 control individuals, 1,000 diverse cases of nonneoplastic diseases, and 1,000 cases of diverse forms of cancer. In 75-80% of the cancer cases distinctive prolongations of the methylene blue reducing times have been noted. No such findings are encountered in the nonneoplastic diseases with the exceptions of cases of pregnancy, tuberculosis, rheumatic fever, and cirrhosis. Further, the elevated reducing times in cancer cases are readily reversible after adequate therapeutic procedures via surgical resection or radiation. These results have been corroborated by various investigators whose combined series total more than 500 cases (personal communication; also discussion by Dr. W. Morris at American College of Chest Physicians, Chicago, 1948).

(3) The following experimental data would indicate that while there is no significant difference in the total reducing groups in the presence or absence of malignancy, there is a decided difference in the time of appearance of these groups under the experimental conditions employed. It is this latter phenomenon which is measured by my technique and which undergoes alteration with malignant disease.

One cc of plasma or serum is mixed with 0.2 of a 15% methylene blue solution in a Wasserman tube. The tube is immersed in a boiling water bath and the time noted for complete decolorization of the dye. This is the usual technique employed by me and referred to as the methylene blue reducing time. On removing the tube, cooling, and agitating, the blue color returns. The tube is then replaced in the boiling water bath, and again the time is noted for complete decolorization of the dye. The second decolorization is found to require less time than the first. This process is repeated until the time for decolorization appears to be constant:

Case	MBT ₁ *	MBT ₂	MBT ₃	MBT ₄	MBT ₅	Diagnosis
C.	15	9.0	5.0	4.0	4.0	Ca. esophagus
F.	13.5	4.0	4.0	Hodgkin's disease
C.	7.5	4.5	4.0	4.0	..	Cholecystitis
M.	11.0	7.0	5.0	3.5	3.5	Ca. tongue

*Methylene blue reducing time in minutes.

These findings indicate that (1) there is no significant difference in the total reducing groups potentially present in the serum of patients with and without malignant disease, as shown by similarity of the final reducing time obtained after multiple heatings; and that (2) this is no way is contradictory to the observation that the initial reducing time in the technique employed is increased in 75-80% of cases of malignant neoplastic disease.

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Silicone Fluid for Sterilization of Dental Hand Pieces

The use of oil heated to high temperatures has been suggested for the sterilization of dental hand pieces. The advantages of oil are that it can be heated to a temperature capable of killing bacteria and that it prevents rusting and dulling and at the same time lubricates metal instruments. The disadvantages are the objectionable odors produced by the cracking of oils when heated at a temperature sufficiently high to kill bacteria, and the low flash points of some of the suggested oils. The addition of aromatic oils has been advocated to mask the odors produced by the cracking of oils. This is not a satisfactory procedure.

We have found that a silicone fluid manufactured by the Dow Corning Company has all the desirable and none of the objectionable features of oil. This fluid had no odor after being held at a temperature of 300° F for more than 1,500 hrs. It has a flash point of 600° F.

Mixtures of freshly isolated saliva, blood, and a culture of *B. subtilis* were used to test the sterilizing efficiency of the silicone fluid. The bacteria were killed when the oil was held at a temperature of 300° F for 10 min, but not at 5 min.

At the present time we are using this method of sterilization only for dental hand pieces. We have reason to believe that it can also be used for hinged metal instruments as well as those that are apt to rust or dull when autoclaved or boiled. Tissue tolerance tests, and the effect on the clostridium group of organisms are now under study. Rubber and cemented instruments cannot be sterilized by this method.

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Varves in the Bed of Lake Erie

In the *Ohio Journal of Science*, 1943, 43, 195-197, Prof. Ira T. Wilson reported a total of 12,223 varves from Sandusky Bay in Lake Erie, representing the minimum time lapse from the Late Maumee stage through the Elkton stage of cold glacial waters. This report has not received the attention it deserves because of doubt that varves were actually present.

Prof. Wilson's method of demonstrating the varves in his smooth clay cylinders was to tear them apart longitudinally. The thin silt layers broke apart at once, but the thicker elastic layers were drawn out into a ragged series of tapering plates before breaking. While these

plates could be counted, the general appearance was different from the graphic color bands ordinarily seen in varve counting. This may account for a certain amount of skepticism.

I have just had the opportunity to inspect sample operations of Prof. Wilson and Alex Ross in southern Lake Erie, east of Green Island, and to secure a sample which they consider to be of glacial origin and varved in the same manner as the Sandusky Bay material. Using a simple method which I have employed to find laminations in peat (*Ecol.*, 1932, 13, 1-6), I froze the material. The ice crystals in the thin layers of coarse material forced the thicker layers apart, giving an appearance much less questionable than that of the jagged plates obtained by tearing. Shaving the side of the frozen core with a safety razor gave a beautiful preparation which leaves no doubt in my mind that varves are present. However, material from the open lake, as might be expected, shows some lenticular intrusions in the varve series.

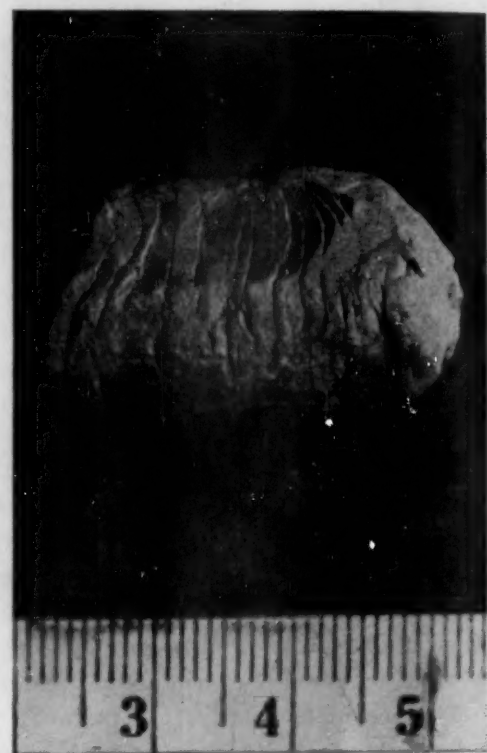


FIG. 1

Fig. 1, taken against a millimeter scale, shows fairly well the effect of freezing. Unfortunately, this core was accidentally thawed, refrozen, and dried before a photograph could be taken. Since drilling has been suspended for the year, fresh specimens are no longer available.

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Book Reviews

Handbook of South American Indians. Vol. 3: *The Tropical Forest tribes*; Vol. 4: *The Circum-Caribbean tribes*. (Bureau of American Ethnology, Smithsonian Institution, Bull. 143). Julian Steward. (Ed.) Washington, D. C.: U. S. Government Printing Office, 1948. Vol. 3: Pp. xxvi + 986; Vol. 4: Pp. xx + 609. (Illustrated.) \$4.50 and \$3.50.

These two volumes contain the factual reports on the tropical lowland peoples of South America—those of the Amazon and Orinoco basins, as well as those of northwestern South America, Central America, and the Andes. They form the middle third of the South American *Handbook* (!) now planned to comprise 7 volumes. Volume 3, of almost a thousand pages, includes the coastal as well as the Amazonian Tupi, the other four regions considered being Matto Grosso and eastern Bolivia, the Montaña and the Yungas of the eastern slopes of the Andes, the western Amazonian basin, and the Guianas. The smaller Volume 4 treats of the peoples northwest of the Orinoco, divided into Colombia and Venezuela, Central America, and the Antilles. As in Volumes 1 (*Marginal tribes*) and 2 (*Andean civilizations*), each consists of a number of articles by authorities of this and the Hispano-American countries and is amply illustrated. Bibliographical references follow each article, with a large bibliography at the back of each book. In the long Introduction to each volume the basic features of the culture of the region are summarized.

The archeology of the extinct groups is considered as well as the ethnology of living peoples, but quantitatively there is a great difference. Naturally, neither volume contains as much archeology as Volume 2, *Andean civilizations*. But the archeology of the tropical forests is so little known and so unimpressive that only two archeological articles, comprising 28 pages, are found in Volume 3. Past cultures are more important in Volume 4 (*Circum-Caribbean*), 6 articles totaling 150 pages, mainly on Central America, being devoted to them. In both volumes, however, writers of individual articles occasionally discuss the archeology of their particular region or tribe. Volume 3 contains 40 signed articles by 15 different authors, but the majority of them are by Curt Nimuendajú and Alfred Métraux. Thirty-nine signed articles by 15 authors compose Volume 4, the major part of the book being the product of Wm. Duncan Strong, Paul Kirchhoff, Frederick Johnson, Irving Rouse, and Gregorio Hernández de Alba.

Apart from the presentation of thousands of facts, the most important part of Volume 3 is Julian Steward's article on "Culture Areas of the Tropical Forests" (pp. 882-899). He distinguishes 6 Basic Tropical Forest cultures: Guianas, Northwest Amazon, Montaña, Juruá-rús, Mojos-Chiquitos, and Tupian; two Sub-Marginal groups, the Western Marginals and the Mura; and three Marginal groups, the Guiana Internal, the Northwestern,

and the Southern Amazon Marginals. The distribution of the Basic Tropical Forest Cultures coincides almost exactly with that of the tropical rain forests, and they are thought to have had their origin in the Circum-Caribbean region and to have been carried up the rivers, mainly by tribes of the Arawak, Carib, and Tupi linguistic families. The diagnostic features of the cultures are the cultivation of tropical root crops, especially bitter manioc; effective river craft; the use of hammocks as beds; and the manufacture of pottery.

Steward's Introduction to Volume 4, "The Circum-Caribbean Tribes: An Introduction," is also most important, as is the short article, "Anthropological Needs and Possibilities in Central America," by Wm. Duncan Strong and Frederick Johnson. The peoples of Central America, the Antilles, and northern Colombia and Venezuela had a complex of traits that characterized them and set them apart from the tribes of the tropical forests; their culture was considerably higher. As the majority of these groups have disappeared, much or most of the data are from historical records. The Circum-Caribbean area is not only the least known of all South America, but is probably the most important to problems of native American culture history. Many basic elements of the Circum-Caribbean region are also basic to Mexican and Andean cultures, and all three are seen as developments from a relatively homogeneous Formative Period, retained in greater simplicity in the Circum-Caribbean region. The Andean features are more numerous than the Mexican ones, indicating that the flow of cultural influence was generally northward.

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Radio aids to navigation. R. A. Smith. Cambridge, Engl.: at the Univ. Press; New York: Macmillan, 1948. Pp. xii + 114. (Illustrated.) \$2.50.

This short account of radio aids to navigation is chiefly concerned with the remarkable development of apparatus for the guidance of aircraft just prior to and during World War II. The author has catalogued the various types: beacons, navigational aids which lay a pattern of coordinates over the ground or water, the radar ranging systems, altimeters, and airplane landing equipment.

Unfortunately, the large number of devices of each type which are mentioned makes the book, in part, simply a listing of apparatus rather than a thorough discussion of any one device. Five types of altimeters, for example, are discussed in the compass of 5 pages, yet the analysis of any one of them is limited to a statement of the frequency range and probable error. Another difficulty is encountered if the reader is unfamiliar with the code names applied to the equipment during its secret development during the war. "Lucero," "Rebeca," "Eureka,"

"Gee," "H₂S," and many other terms are difficult to keep in mind, even with the help of the appended glossary.

The book makes a definite contribution by providing a reference in which the code names of equipment developed during the war may be deciphered and by tabulating the advantages and disadvantages of radio navigational equipment and of the frequencies in common use. It definitely is not a treatise on the subject, nor does it provide a complete analysis of the problems of the application of radio aids to navigation.

G. H. FETT

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Encyclopedia of medical sources. Emerson Crosby Kelly. Baltimore: Williams & Wilkins, 1948. Pp. v+476. \$7.50.

There is currently on the air a radio program entitled "Who Said That?" The announcer reads some provocative phrase enunciated by some newsworthy personage, and several guest "experts" attempt to guess who said it. If the announcer, instead of using current news as a source, were to take his materials for a quiz on "who wrote that" or "who discovered that" from the field of medical history, he could find no more convenient mine of information than Kelly's *Encyclopedia of medical sources*. If this book does not contain all the answers, it still contains enough to win for Dr. Kelly the admiration and gratitude of those, especially librarians, who spend long, tedious hours searching for elusive references, especially in the field covered by this compilation.

Should one wish to read the original description of Babinski's sign, Charcot's disease, or Froehlich's syndrome or use Giemsa's stain, Hitchen's agar or Pool's meningescope, this book will provide the exact reference. These are arranged alphabetically by author and include nationality, dates of birth and death, and the discovery or discoveries for which the doctor or scientist is known. The full title (in original language) and exact citation to journal or book are also given. A subject index is provided.

MORRIS C. LEIKIND

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